EFFECTS OF FLEXIBILITY TRAINING ON BUTTERFLY KICK PERFORMANCE AND LOWER BACK AND HIP FLEXIBILITY

by

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B.S. Biology, State University College of New York at Oneonta, 1974

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Health, Physical Education and Recreation

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1980

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ACKNOWLEDGEMENTS

This writer wishes to express his thanks to Dr. Robert Johnson and Dr. Michael Rubison for their short notice assistance. Thanks to Helena Orazem and Ann Fields for appearing as photographic subjects. Much thanks to Ellen Smith for her support and confidence in me. Finally, my most sincere gratitude and appreciation go to Dr. Larry Noble, whose guidance and consistent dependable support helped make this writing possible.

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PREFACE

This thesis was written to fulfill one of the requirements of the master of science degree in the Department of Health, Physical Education and Recreation at Kansas State University in the summer 1980.

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Chapter 1

THE PROBLEM

The effectiveness of improving athletic performance by training has been well established (3, 4, 48). However, no consensus of opinion exists as to what type of training produces the greatest benefits most efficiently in swimmers (13, 21). A number of coaches have expounded on the benefits of dry land training for competitive swimmers (9, 15, 20, 28, 34, 40), and some experts have stated that training exclusively in the water will not develop maximum swimming ability (6, 16, 21, 36, 43, 47). Despite the possible benefits, the use of practice time for dry land training is always suspect because many competitive swimming seasons are short and practice and water time is always at a premium.

Muscular strength and flexibility may be developed faster on land than in the water (7, 16, 21, 43). Dry land training for competitive swimming is used most extensively to develop these two aspects of fitness (16, 21, 23, 28, 43). Flexibility and strength are necessary for performance of the proper swimming strokes vital to competitive swimming success (21, 23). Proper stroke mechanics are especially critical in butterfly (35). Effective butterfly form is impossible without an effective kick and an efficient butterfly kick requires lower back and hip muscular strength and flexibility (5, 8, 17, 24, 25, 26, 32, 35, 39, 41, 45, 47).

This study was conducted because of the need to develop a safe, short term, time and money efficient dry land training program to improve

lower back and hip flexibility and thus butterfly kicking performance.

Statement of the Problem

This study investigated the effect of a dry land training regime on butterfly kicking performance. More specifically, the study sought to determine the effect, if any, of a program of three sets of ten repetitions of back raises alternated with three ten second repetitions of a lower trunk stretcher exercise performed once a day, five days per week for six weeks on butterfly kick performance. The effect on performance was measured with a timed kick test.

A second problem was to determine what effect, if any, the training regime had on the range of motion of the hip and lower back in extension.

Hypotheses

The training regime has a positive effect on butterfly kick performance. The training regime has a positive effect on lower back and hip flexibility.

Limitations

The validity of the results of this study have been limited by the following:

1. A relatively small number of subjects participated in the study. Small sample sizes result in relatively low statistical power.

2. The use of a human rater in the measuring technique may have effected the validity of the results.

3. The physical activity on the test day was not controlled preceding the pretests or posttests. The scores on the tests could have been depressed due to fatigue.

4. Concurrent with the study some of the subjects were engaged in other exercise activities. These additional programs could have produced effects on the kicking and flexibility not due to the treatment alone.

5. Motivational level was not monitored, some of the subjects participated in a competition one week prior to the posttest.

Delimitations

The boundaries of the observations and variables were delimited by the following:

1. The subjects were 22 volunteer AAU age group swimmers in Manhattan, Kansas in the fall 1979.

2. The experimental training period consisted of six weeks. The observations in the study may not be inferred to training periods of longer or shorter duration.

3. One type of test, a 20 yard timed kick, was administered to measure kick performance.

4. One type of test was administered to measure lower back and hip flexibility in extension.

5. Two exercises were used in the training. A static back arch and a back raise exercise.

Chapter 2

REVIEW OF LITERATURE

This chapter contains a thorough review of literature dealing with: (1) the relationship between butterfly kick performance and back and hip flexibility and (2) dry land flexibility training. More specifically, this chapter contains a discussion of literature pertaining to the association between hip and lower back flexibility and butterfly kick and dry land training for swimmers designed to increase or maintain hip and lower back flexibility in extension.

Relationship Between Butterfly Kick Performance and Lower Back and Hip Flexibility

This section is divided into two parts: part one presents literature which pertains to the relationship between lower back movement and butterfly kick performance and part two pertains to the relationship between hip movement and butterfly kick performance. Most of the information concerning the biomechanics of butterfly kick is based on observations and cinematographic analyses of superior performers.

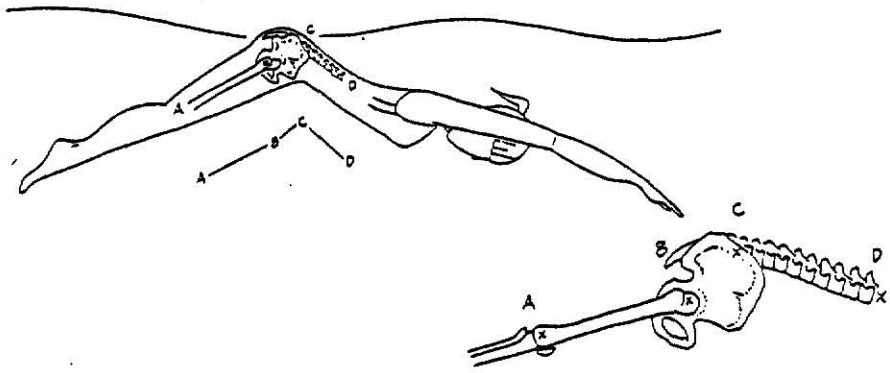
Back Movements

Only one mechanical analysis was found, therefore the remainder of this section presents observations of expert coaches and swimmers.

Barthels and Adrian (5) attempted to identify differences and similarities in hip, knee and ankle joint flexions and extensions of dolphin kick patterns under four conditions, and to identify the degree to which rectus abdominus, lumbar erector spinae, rectus femoris and biceps femoris and tibialis anterior and medial gastrocnemis functioned during each condition. Data was collected from four intercollegiate swimmers using direct-lead electrogoniometry and electromyography with a five-channel pen recorder. Each subject performed three sets of four trials of 25 yards. Each set of trials consisted of: 1) kicking with legs only with a kick board at warmup speed, 2) kicking with legs only with a kick board at sprint speed, 3) full stroke at warmup speed, and 4) full stroke at sprint speed. Goniograms were obtained during all trials. Electromyograms were obtained from one pair of antagonistic muscles in each set. The electrogoniometers were calibrated with a calibration protractor. Maximal isometric contractions with electrodes in place were performed to set a standard for later percent of maximum comparisons. A greater hip amplitude and smaller knee amplitude was directly related to a higher velocity at warmup speed, but no relationship was evident at sprint speed. The first kick was characterized by maximum knee and hip extension occurring simultaneously, followed by maximum knee flexion preceding maximum hip flexion in three of the four subjects. Maximum hip extension started before and continued longer than maximum knee extension, in the second kick and maximum knee flexion preceded maximum hip flexion in a manner similar to that of the first kick. In general the muscle activity was greater for the sprint

speed than the respective slow speed condition. Reciprocal innervation phenomena for the trunk muscles was noted for all subjects during all conditions except one subject under slow condition and one under sprint condition. This phenomena was not as common for the thigh or leg muscles where continuous activity was the common pattern. The erector spinae showed periodic activity preceding and during hip extensions. Barthels and Adrian said the results of the investigation indicate the role of erector spinae and rectus abdominus in trunk stabilization and spinal flexion and extension. The activity of these muscles indicated an active participation by the trunk as an inherent part of the total kicking movement. Barthels and Adrian further said the results indicate no statement can be made regarding joint amplitude desireable for optimal performance of the butterfly stroke.

Collis and Kirchhoff (8) pointed out the basic difference between correct and incorrect hip flexion. Correct hip flexion is accompanied by a hyperextension of the back. Incorrect flexion is produced by a tightening of the abdominal muscles and flexion of the spine so it rotates downward. Correct kicking action enables the feet to kick down and back. The hyperextension of the back helps the swimmer maintain streamlining by limiting the vertical movement of the shoulders. (See Figure 1).



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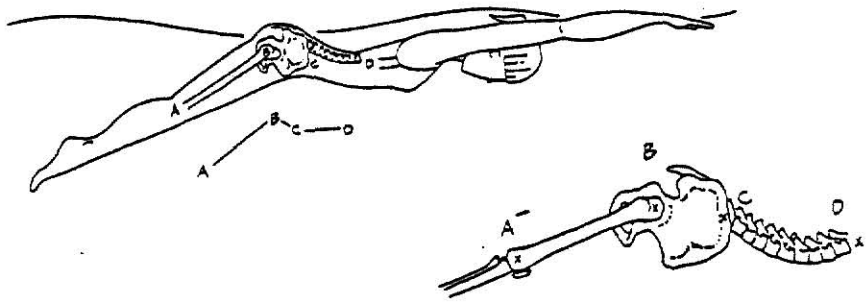

Correct

Figure 1

Correct and Incorrect Butterfly Kick

Kiphuth (25) described the sequential motions of the back and abdomen. The back is arched and pelvic girdle rolled forward when the feet reach their lowest point. This tilting of the pelvis and arching of the back allows both the shoulders and legs to stay near the surface. Kiphuth stated that the alternate flexion-extension of the lumbar spine produces the alternate arching partial pike that initiates the upbeat and downbeat of the butterfly kick. The vertical velocity increases distally to each end of the body starting from the site of initiation in the lumbar spine.

Torney and Clayton (45) and Silverberg (39) emphasized undulation of the spine and legs. They identified the rigid non-undulating spine as a common error.

Armbruster, Musker and Mood (2) said proper performance of the kick requires relaxation of the spine from the shoulders to the hips. Armbruster, Allen and Billingsley (1) wrote both the legs and trunk weave up and down in the water placing the axis of rotation somewhere in the spine.

Spitz and Lemond (41) described the kick action as a smooth easy motion with the ankles relaxed and waist and knees bending. They associated back strength and flexibility with champion butterfliers.

Several experts have identified the lower back as the region of kick initiation. Hale (17) stated the action is initiated in the lumbar spine and sequentially moves to either end of the body. The head and shoulders and feet move vertically with the spine action. The feet move more than the head and shoulders. Tilting of the hips by flexing and extending the lumbar spine can place the feet and lower leg at a better

angle with the water. Hatano (18) examined films of Olympic medalist Gary Hall and commented on observed hip angle changes in his butterfly stroke.

Wilkie and Still (47) said the flow must originate in the hips and upper body and the thighs and hips must not be rigid. A swimming drill used extensively by international calibre swimmer Ian Black was credited with developing lower back suppleness, power and lift, qualities important to Black's high riding style.

Northrip, Logan and McKinney (31) stated that the primary propulsive movement in the butterfly kick is a lumbar-thoracic flexion-extension-hyperextension.

Madders (26) after examining films of a butterfly swimmer, wrote that the lower back initiates the undulation of the lower body and the thoracic vertebrae move in response to the larger motions of the more flexible lower back. The kick is similar to the crawl kick with the lower back movement added to the feet and leg action. Madders determined the body wave moves backwards relative to the water, thus fulfilling one of the conditions necessary for undulatory motion. Hay (19) also noted slight differences in the inclinations of the trunk in the butterfly and crawl kicks.

Hip Movements

Cinematographic and mechanical analyses concerning hip movement and butterfly kick were not found, therefore this section presents observations of expert coaches and swimmers.

Easterling (14) emphasized vertical hip movement and limited vertical movement of the head and shoulders. The hips should move

vertically toward the surface in response to the leg downbeat, but all the energy of the downbeat should not be absorbed by them. Flexibility of the hip and lower back is necessary for: 1)the head and shoulders to not move, 2) the hips to move and 3) the feet and lower legs to push back or not slap up and down on the water. (See Figure 1).

Counsilman (11) wrote "butterfliers with proper strokes say they feel a flowing motion in their bodies ..." (p. 68). He said that an excessive piking action of the hips yields wasted motion. The swimmer should control up and down motion of the body and feel the hips rise and fall slightly as the feet and legs are kicked down and up. The hips should be close to the surface and body position relatively horizontal. Flexibility of the lower back and hips is essential for the hips to move and the shoulders and head remain stable vertically.

VanRossen (46) stressed a "popping" of the hips to transfer momentum from the hips to the upper body. He said the hips and pelvis arch so the whole body can flow. Stephens (42) also encouraged beginners to develop a flow or natural undulating motion with the hips and legs.

Initiation of the kick in the hips was recommended by Shaw (38), Colwin (9) and Schultz and Jensen (37). Jensen and McIlwain (24) examined films of two international calibre swimmers. They observed moment curves following a sequence from the hip to knee to ankle indicating the action was initiated in the hips.

Dry Land Flexibility Training

This section contains a review of literature concerned with dry land training for swimmers designed to increase or maintain lower

back and hip flexibility and strength in extension. Little scientific research has been done concerning dry land training for swimmers. Most programs have been modified from older programs with the coaches considering stroke mechanics, scientific training principles and the needs of the particular swimmers involved. With the exception of the first three studies, this section contains a review of the comments and recommendations of expert coaches concerning back and hip flexibility land training.

Cureton (12) compared Springfield College male freshmen with the Yale University swim team in four flexibility measures. The swimmers scored substantially higher than the Springfield freshmen on all four measures including back extension measured with a prone back arch test. The comparison was replicated in 1932 and 1936 yielding similar results. Cureton concluded the measurements indicate significant differences in flexibility paralleling group differences in swimming ability. The differences were not attributed to either selection or conditioning. Maglischo (27) disagreed with Cureton (12). Maglischo reasoned trunk flexion and extension is unimportant, because it does not occur to any degree in any of the competitive strokes.

Patterson (32) studied the effects of a season of competitive swim training on 12 females aged 12 to 17. The training was swimming and pulley and isometric land exercises. Strength and flexibility measurements for hip extension and trunk flexion and extension were made before and after the training season and mean differences statistically tested at the .05 level. The swimmers specializing in the butterfly stroke improve more in hip flexion and extension than the swimmers with other specialities, but the differences were not significant. Based on the

findings of the investigation Patterson concluded flexion and extension of the hip appeared to be emphasized in dolphin kick.

Mutoh (30) investigated the occurrence of lower back pain in 53 Japanese competitive swimmers aged 13 to 21. Individual low back pain case histories, evaluations of low back flexibility and strength, x-rays of the lumbar spine, and orthopaedic examinations were made. Thirty-two of the 53 swimmers experienced low back pain, and 22 of these experienced pain during or immediately after swimming or land exercises. The percentage of swimmers experiencing low back pain and showing abnormalities tended to be higher in butterfliers than nonbutterfliers. Butterfliers tended to show greater back and muscle strength than nonbutterfliers. Mutoh made the following comments concerning butterfly swimming:

1. Repeated stress is directed to the lower lumbar spine by vigorous extension of the back by the dolphin kick.

2. Specialists in the stroke seem to have stronger spine extensors than flexors, because of the kick and breathing techniques.

3. It is assumed the stroke requires vigorous spine extensors.

4. Exercises to strengthen the muscles related to the lower back are very important.

Power (33) recommended use of flexibility and strength exercise for the prevention of swimming related injuries. A limited range of motion can force an individual to repeatedly be exercising a joint in the extreme outer limits of movement, and this repeated movement during swimming can lead to chronic inflammation. A lack of sufficient range is usually found in the shoulders and flexion and extension of the back. Exercises to increase flexibility work near the limits of range of motion

must be done slowly and only after a warmup. Stretching should be done everyday and the final position held for ten seconds. The following exercises for hip and back extension flexibility were included: (1) prone back hyperextension with arms pushing off the floor hyperextending the spine, (2) prone back hyperextension with the hands grasping the feet behind the back, (3) a kneeling back hyperextension with the hands grasping the feet behind the back, and (4) a wrestler's bridge. Back strength exercises included: (1) the first exercise listed above for flexibility, (2) a prone back hyperextension with the hands behind the head, and (3) a back hyperextension with the hands held in front of the face. All exercises were performed statically with the positions held for 10 seconds.

Kiphuth (25) pioneered dry land training for swimmers at Yale University. Among the many exercises, he outlined four to strengthen and stretch the lower back and hip: (1) a supine back arch, (2) a prone back arch with the arms extended or fingers laced behind the head and feet unanchored, (3) a prone leg elevation, and (4) a static prone back arch with alternate adductions and abductions of the arms. All exercises were to be performed 20 to 50 times.

Heffner (20) emphasized that the flexion and extension exercises prescribed by Kiphuth (25) were excellent. He employed a preseason program including the stretching exercises recommended by Kiphuth. Talbot (43) recommended the use of exercises outlined by Kiphuth, but recommended 20 to 30 repetitions with 20 pushups between each exercise. Miller (29) also included three sets of ten repetitions of a back hyperextension exercise in his preseason dry land program.

Ryan (34) recommended: (1) a back hyperextension with the head

held stationary and the feet flutter kicked in the air, (2) a back hyperextension with legs alternately elevated, (3) a leg elevation with the hands in the anatomical position, and (4) a back hyperextension with the hands held behind the head. Colwin (9) also recommended back hyperextension exercises with: (1) the hands behind the head and (2) the arms in the anatomical position.

Gallagher (16) recommended many repetitions with the stretched position held for 5 or 6 not 10 seconds. He suggested flexibility drills to increase and maintain flexibility and to warmup. The following exercises for back extension range of motion were included: (1) twelve repetitions of a back hyperextension with the feet grasped behind the back, (2) a static back hyperextension with the arms rhythmically adducted and abducted 45 times, (3) 25 repetitions of a back hyperextension with the arms extended and the feet anchored, (4) 25 repetitions of a leg exercise with the arms under the chin and the shoulders anchored, and (5) 25 repetitions of back hyperextension with hands behind the neck and feet anchored.

Holmyard (22) included two exercises for spine mobility in his land program: (1) a prone back hyperextension with the hands behind the neck, and (2) a ballistic back hyperextension combined with a vertical jump. Three sets of 10 to 20 repetitions of each were incorporated in a circuit training schedule.

Hogg (21) prescribed a back hyperextension with extended arms and anchored feet and a static back hyperextension exercise. The latter was to be performed with four to six two-second repetitions with the arms extended supporting the elevated head and shoulders. The exercise was used to increase ease of movement in the lumbar spine and stretch the abdominal muscles.

Wilkie (47) recommended three exercises: (1) a back hyperextension with the hands on the floor and the arms extended forcing the shoulders back, (2) a back hyperextension similar to (1) above with the knees flexed, and (3) a 10 second kneeling back hyperextension.

Compertone (10) used a series of modified yoga exercises to warm-up and develop flexibility. One position in a series with regulated breathing placed the hands on the floor and the back hyperextended. A second position, held for 10 seconds, hyperextended the back by reaching behind the back and raising the head and shoulders and feet while in the prone position. Thompson and Wells (44) included a static back arch exercise also. The exercise requiring the arms be held away from the body was listed as a strength and flexibility exercise.

Schubert (36) used a ballistic type stretching to increase flexibility. A wrestler's bridge type exercise for the trunk was included in the stretching program. Bernal (6) also recommended a wrestler's bridge exercise and a back hyperextension with the hands grasping the feet behind the back.

Summary

This chapter has briefly discussed the literature dealing with the association between hip and lower back flexibility and butterfly kick. The experts (5, 8, 9, 11, 14, 17, 18, 19, 21, 24, 25, 26, 31, 37, 38, 39, 41, 42, 45, 46, 47) seemed to concur that extensive motion of the hip and lower back accompanied proper butterfly kick, but no consensus existed regarding the exact nature of the movements. Numerous experts (6, 10, 12, 16, 20, 21, 22, 25, 27, 29, 30, 32, 33, 34, 36, 43, 44, 47) have recommended

some form of back hyperextension exercise for the development of hip and lower back extension flexibility and strength. Little scientific investigation has been done dealing with either butterfly kick stroke mechanics or dry land training for swimmers to develop back and hip extension flexibility and strength.

Chapter 3

PROCEDURES

This chapter outlines the procedures used in conducting this study. The chapter elaborates on the following topics: (1) subjects, (2) tests, (3) treatments, and (4) statistical method.

The study was conducted at Kansas State University in Manhattan, Kansas. The University natatorium and 25 yard pool were used for the treatment and tests. A proposal of the study was approved by the human rights committee. All subjects and parents of minors were required to sign an informed consent form. APPENDIX A contains a sample of this form.

Subjects

This section discusses how the subjects were selected and some of their characteristics.[1] The subjects were 7 male and 15 female age-group swimmers who volunteered to participate. The subjects possessed varying amounts of swimming ability and experience; three of the subjects had AAU butterfly swimming classifications of A, two were classified B, and 17 were classified C.[2] All subjects were required to possess a minimal level of butterfly kicking proficiency.[3] The age range was six

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[1] The raw data collected from the subjects can be found in APPENDIX C, and descriptive statistics found in Table 3, page 29.

[2] The American Swim Coaches Association establishes National Age Group Time Standards based on percentages of the top ten times of the previous year. APPENDIX B lists the butterfly times for 1979.

[3] Possession of minimal proficiency was determined by visual inspection, with the investigator looking for excessive bending of the knees and any rule infractions.

years eight months to 16 years seven months, with a mean and standard deviation of 11 years 4.36 months ± two years 10.26 months. The subjects ranged in height from 46.75 to 71 inches at the time of the pretest and 47.0 to 70.75 inches at the time of the posttest. The height means and standard deviations were 58.32 ± 5.26 and 58.69 ± 6.78 inches for the pretest and posttest, respectively. The subjects' weights ranged from 44.5 to 146 pounds and 45 to 147.5 pounds on the pretest and posttest, respectively. The weight means and standard deviations were 89.45 ± 29.17 and 91.42 ± 30.41 pounds for the pretest and posttest, respectively.

Tests

This section discusses the tests and testing procedures. Butterfly kick performance and lower back and hip flexibility tests were administered to all subjects prior to and at the conclusion of the training period. Pretest and posttest were given at the same time of day. The principle investigator did all testing. No extrinsic motivators, such as verbal encouragement, were applied.

Butterfly Kick Performance

Kick performance measures were made using a 20 yard timed kick test. The subjects' test scores were the best of two trials. A rest period of at least five minutes separated the trials. A warm-up period of at least ten minutes preceded the testing. The warm-up consisted of kicking and swimming. Two subjects were tested simultaneously. The starting commands and proper kickboard use procedures were explained to the subjects. Kickboards[1] were held in front of the head with the arms

[1]Standard 1¼ by 12 by 18 inch kickboards were used.

extended and the hands grasping the sides of the board halfway between the ends. A preparatory signal and starting command: "ready. go", were given when the subjects appeared ready. Instructions to push off the wall in the prone position and kick as fast as possible to the far end of the pool using a legal butterfly kick only were given to the subjects. The pushoff technique was not controlled. The administrator was positioned to sight along the five yard mark for the start and the 25 yard mark, end of the pool, for the finish. Times were recorded between five and 25 yards, with the timer started and stopped when the kickboard broke the plane at the five and 25 yard marks.

Lower Back and Hip Flexibility

Flexibility measures were recorded using a prone back arch test. The subjects' test scores were the best of two trials. More trials were made if the subject requested it. A rest period of at least one minute separated the trials. A warm-up consisting of one set of ten repetitions of the back raise exercise and one ten second lower trunk stretcher exercise preceded the testing. The fingers were laced behind the neck or head as the subject lay prone on the pool deck. The chin was lifted as high as possible off the floor upon the command to start. The feet were not anchored. A yard stick was held vertically in a position near the subjects' chin. The highest steady point reached by the chin was observed and the distance measured above the floor in inches was recorded as the flexibility test score. The line of sight of the administrator was kept horizontal at the subjects' chin height. Figure 2 illustrates the proper position.

Treatments

All training sessions were supervised and extrinsic motivation was applied in an attempt to keep motivation high. The regime was performed once a day five days per week for six weeks. The training started the day after the pretest and continued until the day before the posttest. Training was done immediately before or after the water workout, on the pool deck.

The training regime for the experimental group consisted of three sets of ten repetitions each of a back raise exercise alternated with three ten second repetitions of a lower trunk stretcher exercise.

The back raise exercise was performed as follows: (1) the subject lay prone on the deck with the arms out to the sides; (2) the feet were not anchored; and (3) the subject raised the head, chest and arms off the deck, reaching as far back as possible, when the command to start was given. Figure 3 illustrates the proper exercise position. The raised position was held for three seconds. Each raised position was followed by a three second rest interval. Ten repetitions were performed for each set.

The lower trunk stretcher exercise was performed as follows: (1) the subject lay prone on the deck, (2) the subject reached behind the back, grasped the feet and lifted the chest and legs off the deck arching the back when the command to start was given. Figure 4 illustrates the proper exercise position. The arched position was held for ten seconds.

The control grpup exercised with a training regime consisting

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of two sets of 15 repetitions each of dips, pushups, situps and glide position stretches.[1]

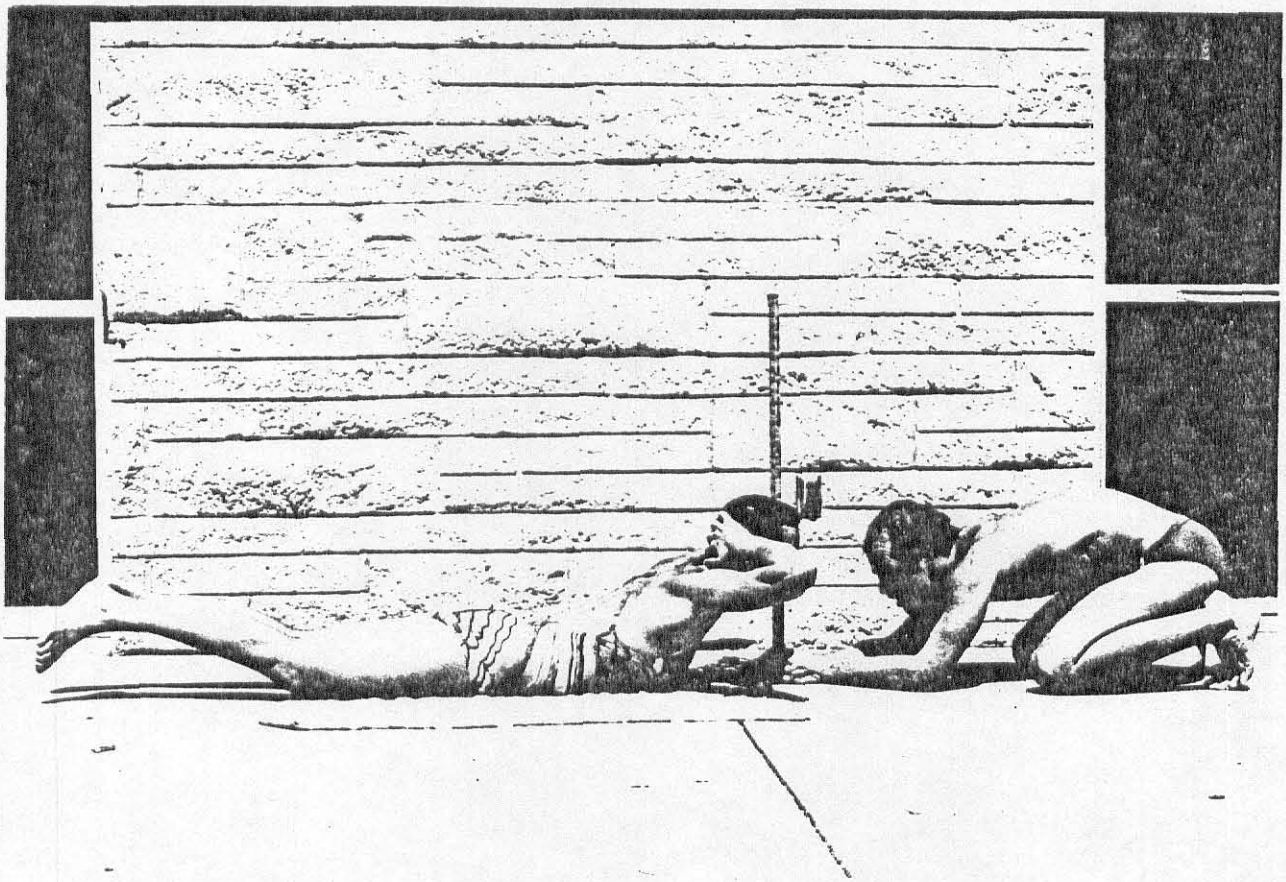

Figure 2

Lower Back Flexibility Test

[1]APPENDIX F Figures 5 and 6 show the dip and glide position stretch positions used by the control group.

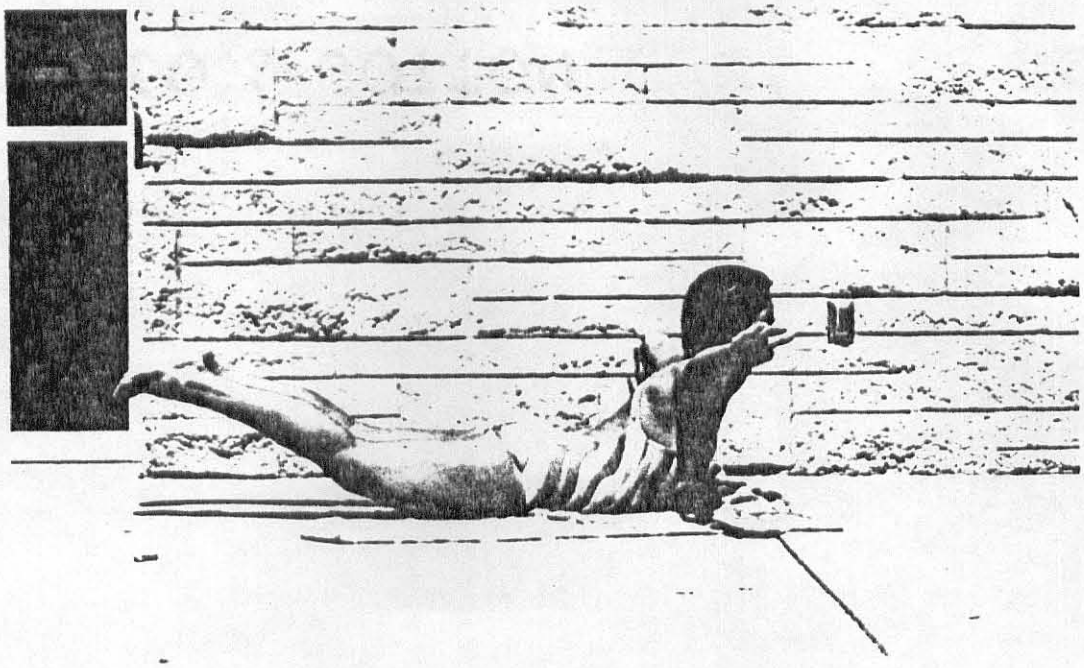

Figure 3

Back Raise Exercise

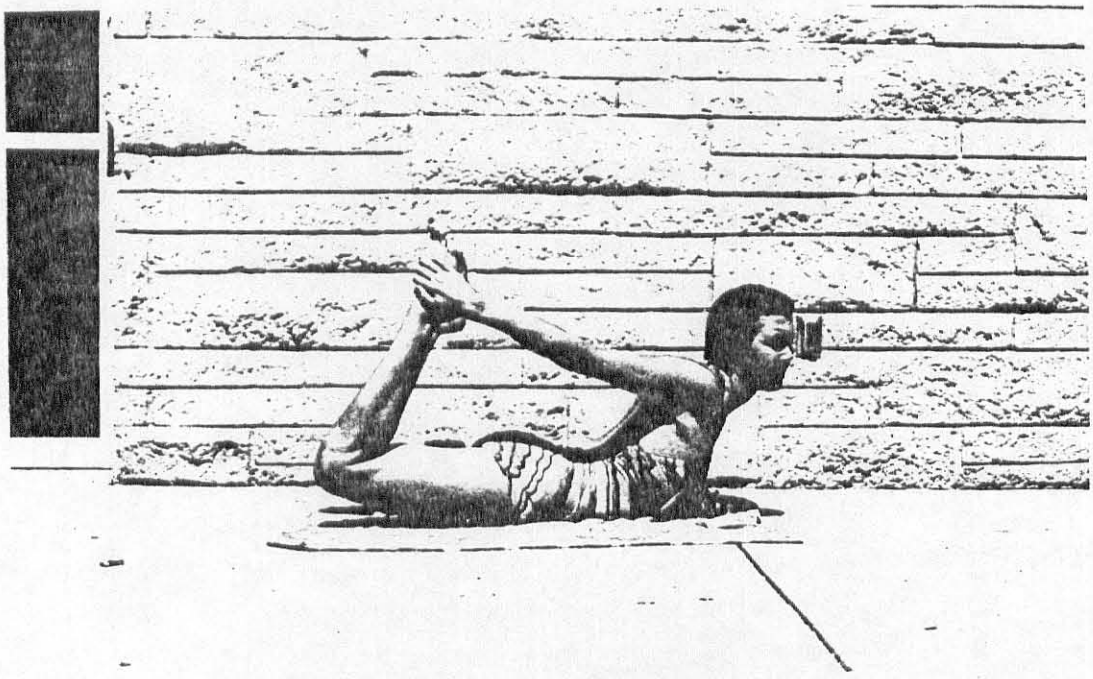

Figure 4

Lower Trunk Stretcher Exercise

Statistical Method

The effect of the treatment on both kick performance and hip and lower back extension was determined using a covariance analysis on posttest scores with the effect of pretest scores removed. The pretest scores in kick performance and back flexibility were the covariates. The kick and flexibility posttest scores were the criterion variables. One-tailed probability was used with the level of significance set at .05.

Chapter 4

RESULTS AND DISCUSSION

This chapter presents the data and contains descriptive statistics, an interpretation of the results and a discussion of the results of this study.

Results

This section is divided into three parts. Part one pertains to the raw data, part two deals with descriptive statistics and the final part is concerned with treatment effects.

Raw Data

Raw data from all subjects, including gender, age, height, weight, AAU butterfly classification and pretest and posttest scores on performance can be found in APPENDIX C.

Flexibility test scores, pretest-posttest difference, means and standard deviations are listed in Table 1. The flexibility posttest scores were higher than pretest scores for 10 of the 11 subjects in the control group, and for 7 of the 11 subjects in the experimental group. One subject in the experimental group scored the same on the flexibility pretest and posttest. The greatest improvements were 3.5 inches, which was 50 percent of the pretest score in the control and 7.5 inches (166.7 percent), in the experimental group. The only pretest-posttest negative change in the control group was 5.2 inches which was 45.8 percent.

Table 1

Flexibility Test Scores and Differences

Control Group Subject	Gender	Flexibility[1] Pretest	Posttest	Posttest-Pretest[1]	Posttest-Pretest / Pretest
01	M	12.0	6.5	-5.5	-0.458
03	F	9.5	11.0	+1.5	+0.158
05	F	9.0	10.0	+1.0	+0.111
06	M	12.5	13.0	+0.5	+0.040
13	F	9.0	11.0	+2.0	+0.222
15	F	11.0	14.5	+3.5	+0.318
16	F	7.0	10.5	+3.5	+0.500
18	F	12.5	15.5	+3.0	+0.240
19	F	15.0	17.0	+2.0	+0.133
20	F	10.0	10.5	+0.5	+0.050
22	M	12.5	13.0	+0.5	+0.040
	x	10.91	12.05	1.14	
	sd.	2.26	2.94	2.48	
Experimental Group					
02	M	10.5	8.5	-2.0	-0.190
04	M	12.5	10.5	-2.0	-0.160
07	F	15.0	13.0	-2.0	-0.133
08	F	11.5	13.0	+1.5	+0.130
09	F	4.5	12.0	+7.5	+1.667
10	F	15.5	20.0	+4.5	+0.290
11	F	7.5	12.0	+4.5	+0.600
12	M	7.5	8.0	+0.5	+0.067
14	F	11.5	11.5	0	0
17	F	4.0	7.0	+3.0	+0.750
21	M	10.5	12.0	+1.5	+0.143
	$\bar{x}$	10.05	11.59	1.55	
	sd.	3.81	3.46	3.10	

[1] All units are in inches.

Three subjects in the experimental group had pretest to posttest negative changes, and all of these changes were at least 2.0 inches or 13.3 percent. Nine of the 17 subjects with posttest scores higher than pretest scores had changes of at least 2.0 inches. Five of these nine were in the control group.

The largest decreases in the control group and experimental group were for male subjects while the largest increases in both groups were for female subjects. Similarly, the largest increase by a male subject was 1.5 inches while nine female subjects showed greater increases.

Butterfly kick test scores, pretest-posttest differences, means and standard deviations are listed in Table 2. The kick posttest times were faster for 7 of the 11 subjects in the control group and 9 of the 11 subjects in the experimental group. The greatest time improvement in the control group was 3.8 seconds which was 13.8 percent. The greatest time improvement in the experimental group was 7.9 seconds while the greatest percentage improvement was 24.6 percent. Six subjects had posttest times slower than pretest; four of these were in the control group. The greatest pretest to posttest time increase in the control group was 1.9 seconds which was 8.6 percent of the pretest; while the greatest time increase in the experimental group was .8 seconds which was 5.1 percent. Nine of the 16 subjects with pretest-posttest negative differences had changes of more than 1.9 seconds or 8.6 percent of the pretest, seven of these were in the experimental group.

The largest performance improvements in the kick test in both the experimental and control groups were for female subjects. The largest performance declines in both groups were for male subjects. For example,

Table 2

Kick Performance Test Scores and Differences

Control Group Subject	Gender	Kick[1] Pretest	Kick[1] Posttest	Posttest-Pretest[1]	Posttest-Pretest / Pretest
01	M	22.1	24.0	+1.9	+0.086
03	F	29.1	28.8	-0.3	-0.010
05	F	22.8	20.0	-2.8	-0.123
06	M	22.1	22.0	-0.1	-0.005
13	F	16.7	16.9	+0.2	-0.012
15	F	21.5	20.7	-0.8	-0.037
16	F	29.4	27.7	-1.7	-0.058
18	F	28.3	29.5	+1.2	+0.042
19	F	19.8	20.0	+0.2	+0.010
20	F	27.5	23.7	-3.8	-0.138
22	M	16.4	16.1	-0.3	-0.018
	$\bar{x}$	23.25	22.67	-0.58	
	sd.	4.73	4.55	1.66	
Experimental Group					
02	M	29.0	26.4	-2.6	-0.090
04	M	45.1	38.6	-6.5	-0.144
07	F	37.8	29.9	-7.9	-0.209
08	F	19.7	20.4	+0.7	+0.036
09	F	43.6	36.0	-7.6	-0.174
10	F	20.6	19.2	-1.4	-0.068
11	F	24.8	24.6	-0.2	-0.008
12	M	29.8	27.2	-2.6	-0.087
14	F	28.0	21.1	-6.9	-0.246
17	F	57.1	51.2	-5.9	-0.103
21	M	15.6	16.4	+0.8	+0.051
	$\bar{x}$	31.92	28.27	-3.65	
	sd.	12.66	10.25	3.40	

[1]All units are in seconds.

the greatest improvement for a male subject was 6.5 seconds, while three females showed greater improvement.

All five subjects with A or B AAU butterfly time classifications had faster times on the kick pretest than posttest, and only one other subject had a pretest performance faster than posttest.

Descriptive Statistics

Descriptive statistics for the control group, experimental group, and groups combined are presented below in Table 3. Means and standard deviations are given for: (1) flexibility pretest, (2) flexibility posttest, (3) kick pretest, and (4) kick posttest.[1]

The flexibility mean for all subjects combined increased 1.34 inches. The variability also increased as indicated by a change in the standard deviation from 3.09 to 3.14 inches. On the kick test the mean for all subjects combined decreased 2.11 seconds, indicating an overall average performance improvement. The standard deviation for all subjects combined on the kick test decreased 2.07 seconds from 10.32 to 8.25 seconds on the pretest and posttest respectively.

The experimental group flexibility mean increased 1.54 inches from 10.05 to 11.59 inches. The variability decreased slightly as indicated by the change in standard deviation 3.81 to 3.46 inches. The kick performance improved 3.65 seconds as indicated by a change in the mean from 31.92 to 28.27 seconds on pretest and posttest respectively. The standard deviation for kick performance decreased 2.4 seconds from 12.65 to 10.25 seconds.

The control group flexibility mean increased 1.14 inches from 10.91 to 12.05 inches. The variability also increased as indicated by a change

[1]Means and standard deviations for (1) age, (2) height pretest, (3) height posttest, (4) weight pretest, and (5) weight posttest are contained in APPENDIX D, Table 7.

Table 3

Descriptive Statistics[1]

	Group	Mean	Standard Deviation	Skewness	Kurtosis
Flexibility Pretest (inches)	Control	10.91	2.26	.049	-.167
	Experimental	10.05	3.81	-.264	-.718
	Combined	10.48	3.09		
Flexibility Posttest (inches)	Control	12.05	2.94	-0.045	.173
	Experimental	11.59	3.46	1.258	3.116
	Combined	11.82	3.14		
Kick Pretest (seconds)	Control	23.25	4.73	-0.012	-1.307
	Experimental	31.92	12.66	7.23	- .131
	Combined	27.58	10.32		
Kick Posttest (seconds)	Control	22.67	4.55	+0.202	-1.047
	Experimental	28.27	10.25	1.169	1.236
	Combined	25.47	8.25		

[1]Data is from 22 subjects, 11 in the control group and 11 in the experimental group.

in the standard deviation from 2.26 to 2.94 inches. The kick performance improved 0.58 seconds. The kick test variability decreased, as indicated by a change in standard deviation 4.73 to 4.55 seconds.

Treatment Effects

Correlation coefficients between pretest and posttest scores for kick performance and flexibility are presented below in Table 4. The pretest-posttest kick correlation coefficient was .971, indicating 94.8 percent of the variability in posttest scores could be attributed to differences in pretest scores. The flexibility pretest-posttest correlation coefficient was .611, which indicates 37.3 percent of the variability in posttest scores could be attributed to differences in pretest scores. Kick scores and flexibility scores were negatively correlated. Increased flexibility, denoted by higher test scores, was associated with faster kick times (lower kick test scores). The maximum predictability of kick scores from flexibility scores was 25 percent, as indicated by the pretest flexibility and posttest kick correlation coefficient of .493. The remaining three correlation coefficients signify between 15 and 21 percent of the kick variability can be predicted from the flexiblity differences. Flexibility and kick performance correlations were stable (-.463 and -.493) from pretest to posttest. However, the correlation coefficients between kick scores and flexibility scores were insignificant.

Table 4

Correlation Coefficients

	Posttest Flexibility	Pretest Kick	Posttest Kick
Pretest Flexibility	.611 (.045)[1]	-.463 (.161)	-.493 (.127)
Posttest Flexibility		-.386 (.250)	-.407 (.211)
Pretest Kick			.971 (0)

[1]Numbers in parenthesis are significance probabilities.

A covariance analysis on posttest scores, with the effect of pretest scores removed, was used to determine the effects of the treatment on both kick performance and hip and lower back extension flexibility. The slopes of the pooled regression lines were tested for significance. The slopes, Beta = .611 for flex tests and Beta = .971 for kick tests, had F-values of 11.894, and 327.782 both highly significant at .05. Application of covariance analysis is dependent on the tenability of the following assumptions:

1. Normal distribution of all groups of scores.
2. Homogeneous variability within groups.
3. The slope of within group regression lines are homogeneous.

None of the data showed significant deviation from normality as indicated by the skewness indices. Therefore, the first assumption of distribution normality was tenable. The variability of the groups was examined to test the second assumption. A marked difference in kick test

variability exists between the experimental and control groups, as indicated by the standard deviations. The variance of the experimental group is approximately six times that of the control group, a statistically significant difference. The average standard deviations for the two kick tests were 4.64 for the control and 11.46 for the experimental groups. This difference between could be attributed to the random assignment of the small groups. Violation of the assumption of homogeneous variability may have affected the precision of the F-test.

Table 5 present the results of covariance analysis. A t-ratio was computed to determine if the experimental and control within group regression line slopes were significantly different. The calculated flexibility and kick t-values of .61 and 1.52, respectively, indicated the slope differences were not significant. Therefore the third assumption of within group regression line homogeneity was tenable.

Table 5

Covariance Analysis

	Slope	Intercept
Flexibility		
Experimental	.582	5.749
Control	.742	3.946
Significance of difference between groups	.55	.942
Kick		
Experimental	.79	3.005
Control	.90	1.685
Significance of difference between groups	.23	.153

The covariance analysis reveals the chance probability of the observed differences between groups for posttest flexibility means was .94. In other words, the difference between group flexibility means is insignificant at the .05 level. The probability of the observed differences between group kick posttest means is .15. This low probability indicates the differences between adjusted group kick posttest means is insignificant at .05. However, the observed difference between group kick means are significant at a much lower level than the observed difference between group flexibility means.

Discussion

At the outset of this experiment, a total of 44 subjects were pretested and randomly assigned to the two groups. By the time the training period elapsed 22 subjects had been dropped from the study as a result of inadequate attendance. The dropped subject mean and standard deviation for flexibility and kick pretest were 11.182 $\pm$ 3.531 and 23.450 $\pm$ 9.447 respectively. Comparison of these dropped subject pretest scores with pretest measure of subjects completing the study indicate little difference between the dropped subjects and those completing the study.

The calculated correlation coefficient between pretest and posttest flexibility test scores was greatly diminished due to the scores of one subject in the control group. Flexibility test scores for this subject, number 01, greatly declined from 12.0 to 6.5 inches; similarly, the kick scores also showed the greatest decline 22.1 to 24.0 seconds. The means on pretest and posttest flexibility scores for the control group would

change from 11.287 to 11.011 and 11.936 to 12.504, respectively and the control group prekick-postflexibility correlation coefficient would change from .074 to .096. This large decline in test scores was possibly due to reduced motivation on the posttests.

The results of this study indicate no significant difference between the treatment and control groups. This may be due to no real training effect. However, the lack of significance could be due to insufficient statistical power. Also, increases in the number of repetitions or repetition duration or lengthened treatment period could have produced different results.

Results of this investigation do not support the stated opinions of experts (6, 10, 13, 16, 20, 21, 22, 25, 27, 29, 30, 32, 33, 34, 36, 43, 44, 47), who advocate the use of back hyperextension type exercises to increase lower back and hip flexibility in extension. Results of this study support the opinions of experts (5, 8, 17, 18, 19, 21, 25, 26, 31, 39, 41, 45, 47) and others (9, 12, 14, 24, 37, 38, 42, 48) who have claimed a relationship between lower back and hip extension flexibility and butterfly kick performance. The lack of observed significant increases in flexibility and kick performance do not conflict with the existence of this relationship.

However these results are specific to the population of subjects in this investigation. The subjects in this study were mostly young C level swimmers with limited swimming experience. The results may not be extended to other populations.

Chapter 5

SUMMARY AND CONCLUSION

This chapter contains a summary of the study and a statement of conclusion regarding the problem statement.

Summary

The purpose of the study was to determine if a dry land training program would affect butterfly kicking performance and lower back and hip flexibility. More specifically, the study sought to determine the effect, if any, of a program of three sets of 10 repetitions of back raises alternated with three 10 second repetitions of lower trunk stretching exercises performed once a day, five days per week for six weeks, on butterfly kick performance and on the range of motion of the hip and lower back in extension.

The volunteer subjects were seven male and 15 female age group swim team members in Manhattan, Kansas in the fall 1979. The subjects had varied amounts of swimming ability and experience. The age of the subjects ranged from six years eight months to 16 years seven months, with a mean of 11 years 4.36 months and a standard deviation of two years 10.26 months. The height of the subjects ranged from three feet 10.75 inches to five feet 11 inches, with a mean height of four feet 10.32 inches and a standard deviation of 6.66 inches. The weight of the subjects ranged from 44.5 to 146 pounds, with a mean of 89.45 pounds and a standard deviation of

29.17 pounds. Three of the subjects had AAU butterfly classifications of A, two were classified B, and 17 were classified C. The subjects were randomly divided into a control and an experimental group. The test for butterfly kick performance was a 20 yard timed kick with a kick board. Each subject was tested before and after the treatment period. A test for range of motion of hip and lower back in extension was also administered prior to and following the treatment. A prone back arch test was used with vertical chin to floor distance the score. All training sessions were supervised and extrinsic motivators in the form of verbal encouragement applied. The regime was performed once a day, five days per week, for six weeks. The training started the day after the pretest and continued until the day before the posttest. Training was done immediately before or after the water workout, on the pool deck. The training regime for the experimental group consisted of three sets of 10 repetitions of a back raise exercise alternated with three 10 second repetitions of a lower trunk stretcher exercise. The training regime for the control group consisted of two sets of 15 repetitions of dips, pushups, situps and glide position stretches. Analysis of covariance indicated no significant differences between the control and treatment groups in either flexibility or kick posttest measures at the .05 level.

Conclusion

Within the limits of the study, the hypotheses that butterfly kicking performance and lower back and hip flexibility is enchanced by training with back raises and lower trunk stretcher exercise were not supported.

Recommendations

The following recommendations might be considered for further study when investigating the effects of flexibility training on butterfly kick performance and lower back and hip extension flexibility.

1. It is recommended that different, related exercises be alternated with those used to help maintain a high level of motivation.

2. It is suggested that the length of the training program be increased.

3. It is recommended that sample size be increased.

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APPENDIX A

INFORMED CONSENT FORM

I, _____, do hereby volunteer to participate in an experiment designed to study the effect of a land stretching program on back flexibility and butterfly kick.

I have been asked to complete the study, but I understand I may drop out at any time.

I understand I will be required to fill out a brief questionnaire concerning my age, height, weight, and competitive experience and will be asked to participate in the practice sessions five days per week for six weeks and the testing sessions which will be two timed butterfly kick tests and two back arch tests. I understand the practice sessions will be 10 to 15 minutes of back stretching exercises.

I understand my personal information and test results will be kept private and will be shown to me, if I ask.

I understand the chances of physical injury are small, but in the event of injury resulting from the study, no financial compensation will be available.

To my knowledge I am in a good state of health and have not had or now have any lower back problems.

I have read, (or had read to me), and understand the above statements and do hereby voluntarily consent to participate as a subject in said study.

_____ (subject signature)

_____ (parent as witness)

_____ (subject name printed)

_____ (date)

APPENDIX B

ASCA Achievement Awards
1979

National Age Group Time Standards

B	A	AA	Long Course	B	A	AA
Girls 10 and Under				Boys 10 and Under		
43.89	40.59	38.89	50 fly	43.69	40.39	38.69
1:40.89	1:32.49	1:28.59	100 fly	1:37.79	1:30.29	1:26.49
Girls 11 & 12				Boys 11 & 12		
40.89	37.79	36.19	50 fly	39.49	36.49	34.99
1:29.69	1:22.79	1:19.29	100 fly	1:27.29	1:20.59	1:17.19
Girls 13 & 14				Boys 13 & 14		
1:24.29	1:17.79	1:14.59	100 fly	1:20.49	1:14.29	1:11.19
3:03.69	2:49.59	2:42.49	200 fly	2:55.79	2:42.29	2:35.49
Girls 15 - 18				Boys 15 - 18		
1:21.69	1:15.39	1:12.29	100 fly	1:14.09	1:08.39	1:05.49
2:47.39	2:43.79	2:36.99	200 fly	2:43.09	2:30.49	2:24.29
B	A	AA	Short Course	B	A	AA
Girls 10 and Under				Boys 10 and Under		
39.39	36.39	34.39	50 fly	38.89	35.89	34.39
1:29.79	1:22.89	1:19.39	100 fly	1:25.69	1:19.19	1:15.89
Girls 11 & 12				Boys 11 & 12		
36.69	33.89	32.89	50 fly	35.39	32.69	31.29
1:20.89	1:14.09	1:10.99	100 fly	1:17.89	1:11.89	1:08.89
Girls 13 & 14				Boys 13 & 14		
1:15.49	1:09.69	1:06.79	100 fly	1:10.79	1:05-39	1:02.59
2:40.99	2:28.59	2:22.39	200 fly	2:36.39	2:24.39	2:18.39
Girls 15 - 18				Boys 15 - 18		
1:12.89	1:07.39	1:04.59	100 fly	1:06.19	1:01.09	58.59
2:38.89	2:26.69	2:20.59	200 fly	2:24.19	2:13.09	2:07.59

APPENDIX C

Table 6

Raw Data

Subject	Group	Gendre	Age[1]	Height[2]		Weight[3]		AAU	Flexibility[2]		Kick[4]	
				Pretest	Posttest	Pretest	Posttest	Classification	Pretest	Posttest	Pretest	Posttest
01	C	M	155	59.25	60.5	86.0	93.0	B	12.0	6.5	22.1	24.0
02	E	M	100	53.0	53.25	70.0	70.0	C	10.5	8.5	29.0	26.4
03	C	F	88	52.75	53.25	69.0	69.5	C	9.5	11.0	29.1	28.8
04	E	M	94	51.5	51.0	68.75	68.0	C	12.5	10.5	45.1	38.6
05	C	F	178	65.5	66.5	122.25	127.0	C	9.0	10.0	22.8	20.0
06	C	M	163	66.75	67.25	126.25	129.0	C	12.5	13.0	22.1	22.0
07	E	F	108	48.5	48.75	54.0	54.0	C	15.0	13.0	37.8	29.9
08	E	F	128	59.25	59.75	85.5	92.0	A	11.5	13.0	19.7	20.4
09	E	F	93	49.0	49.25	52.0	52.5	C	4.5	12.0	43.6	36.0
10	E	F	170	63.5	63.75	113.0	116.0	C	15.5	20.0	20.6	19.2
11	E	F	127	57.0	57.5	86.75	87.75	C	7.5	12.0	24.8	24.6
12	E	M	160	57.5	57.75	66.0	69.5	C	7.5	8.0	29.8	27.2
13	C	F	157	64.0	64.5	126.0	133.75	A	9.0	11.0	16.7	16.9
14	E	F	133	57.0	57.5	75.0	75.5	C	11.5	11.5	28.0	21.1
15	C	F	149	58.75	59.0	88.0	84.0	C	11.0	14.5	21.5	20.7
16	C	F	153	65.75	66.25	101.0	102.0	C	7.0	10.5	29.4	27.7
17	E	F	80	46.75	47.0	44.5	45.0	C	4.0	7.0	57.1	51.2
18	C	F	121	57.25	57.25	83.0	86.0	C	12.5	15.5	28.3	29.5
19	C	F	136	57.5	57.75	93.5	93.75	B	15.0	17.0	19.8	20.0
20	C	F	115	54.0	54.5	67.5	68.0	C	10.0	10.5	27.5	23.7
21	E	M	193	71.0	70.75	146.0	147.5	A	10.5	12.0	15.6	16.4
22	C	M	199	67.5	68.25	144.0	147.5	C	12.5	13.0	16.4	16.1

[1]All units are in months.
[2]All units are in inches.
[3]All units are in pounds.
[4]All units are in seconds.

APPENDIX D

Table 7

Subject Characteristics Descriptive Statistics[1]

	Group	Mean	Standard deviation
Age (months)	Control	146.73	30.70
	Experimental	126.0	35.87
	Combined	136.36	34.26
Height Pretest (inches)	Control	60.82	5.28
	Experimental	55.82	7.18
	Combined	58.32	6.66
Height Posttest (inches)	Control	61.36	5.40
	Experimental	56.02	7.15
	Combined	58.69	6.76
Weight Pretest (pounds)	Control	100.59	25.46
	Experimental	78.32	29.42
	Combined	89.75	29.17
Weight Posttest (pounds)	Control	103.05	27.13
	Experimental	79.80	30.15
	Combined	91.42	30.41

[1]Data is from 22 subjects, 11 in the control group and 11 in the experimental group.

APPENDIX E

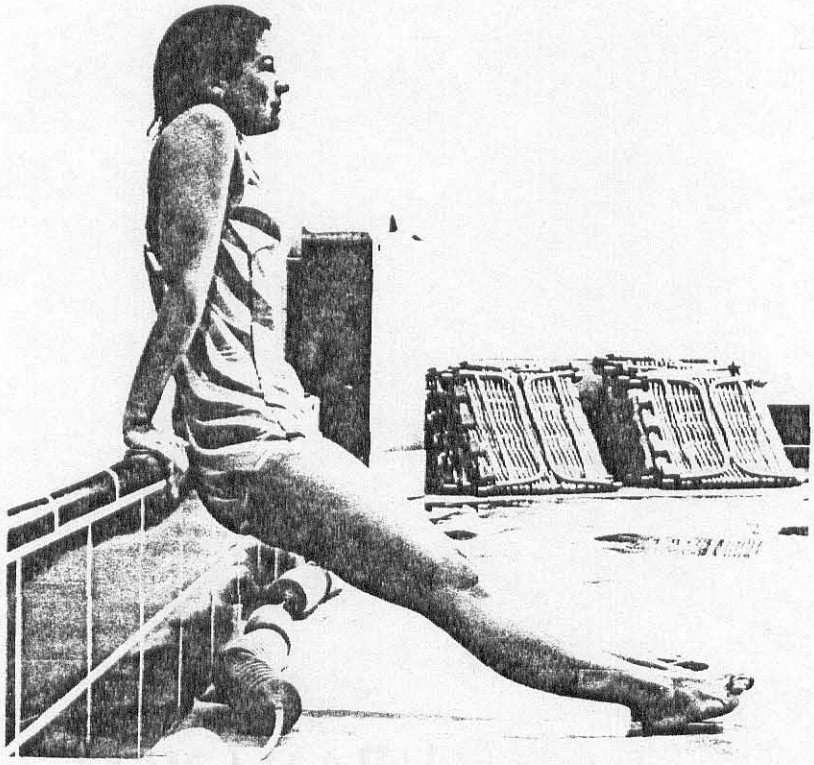

Figure 5

Dip Exercise

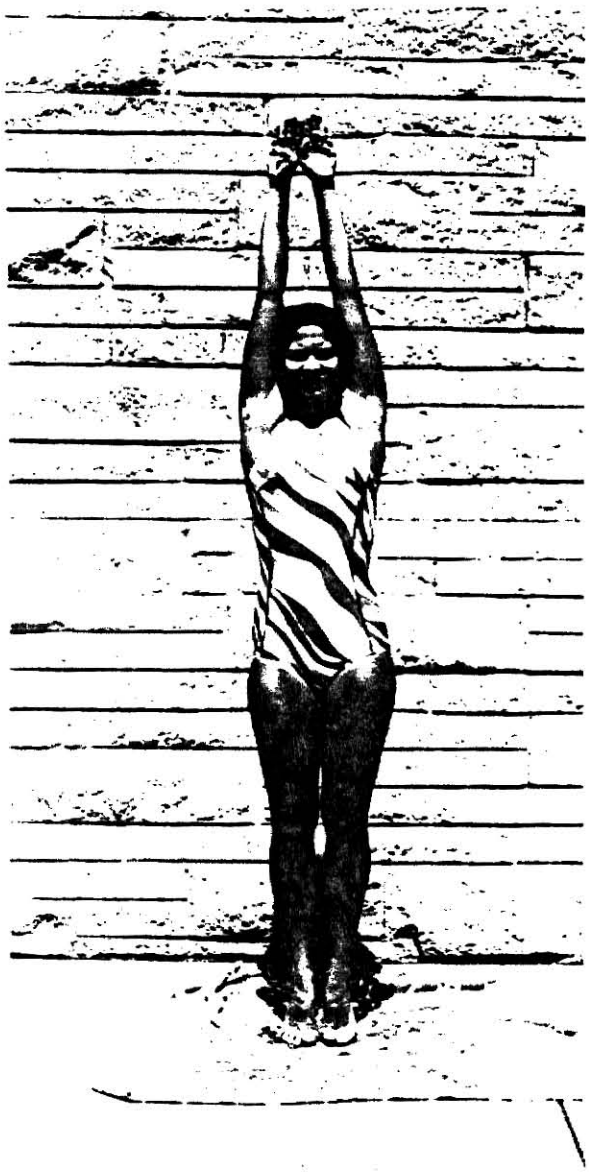

Figure 6

Glide Position Stretch

EFFECTS OF FLEXIBILITY TRAINING ON BUTTERFLY KICK PERFORMANCE AND LOWER BACK AND HIP FLEXIBILITY

by

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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Health Physical Education and Recreation

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1980

The purpose of this study was to investigate the effect, if any, of a dry land training program on butterfly kick performance, and on the range of motion of the hip and lower back in extension. The volunteer subjects were 22 male and female age group swimmers in Manhattan, Kansas in the fall 1979. The subjects possessed varied amounts of experience and ability, but all possessed a minimal level of butterfly kicking proficiency. The subjects were randomly divided into the experimental and control groups. The test for kick performance was a 20 yard timed kick with a kick board. The test for range of motion was a prone back arch test with the vertical chin to floor distance the score. Both tests were administered to each subject prior to and following the treatment. All training sessions were supervised and held on the pool deck before or after the water workout. The experimental group training regime consisted of three sets of ten repetitions of back raises alternated with three ten second repetitions of a lower trunk stretcher exercise. The control group trained with two sets of 15 repetitions of dips, pushups, situps and glide positions stretches. Both groups trained once a day five days per week for six weeks. Covariance analysis indicated no significant differences between the control and experimental groups in either flexibility or kick posttest measures at the .05 level. Within the limits of the study, the hypotheses that butterfly kicking performance and lower back and hip flexibility are enhanced by training with back raises and lower trunk stretcher exercise were not supported.