WISCONSIN STATE UNIVERSITY - LA CROSSE

GRADUATE COLLEGE

Candidate: Richard T. Malstrom

I recommend acceptance of this seminar paper to the Graduate College in partial fulfillment of this candidate's requirements for the degree Master of Science.
The candidate has completed his oral seminar report.

8/7/69
Date

Frances Carter
Seminar Paper Advisor

This seminar paper is approved for the Graduate College:

August 8, 1969
Date

James H. McEnelson
Dean, Graduate College

A COMPARATIVE STUDY OF STATIC AND BALLISTIC STRETCHING TECHNIQUES FOR THE ATTAINMENT AND RETENTION OF FLEXIBILITY

BY

RICHARD T. MALSTROM

ABSTRACT

Sixty freshmen high school boys from Medford, Wisconsin, were divided into three groups by random selection. A pre test for trunk-hip flexibility was administered to each group. A flexibility development program of four weeks duration (four times a week) was conducted, and then six post tests were taken at one week intervals. For the flexibility development program one group performed static stretching exercises, one group performed ballistic stretching exercises, and the control group did not participate in the flexibility development program.

The design of the study was a two factor experiment. The analysis of variance technique was applied to the data. A significant improvement in trunk-hip flexibility was obtained by both the ballistic and static stretching exercises; however, flexibility of the trunk and hips attained through the static stretching technique was attained longer.

Tests for interaction between tests and methods indicated that there were uncontrolled variables - perhaps learning and motivation - operating during this investigation.

A COMPARATIVE STUDY OF STATIC AND BALLISTIC STRETCHING TECHNIQUES FOR THE ATTAINMENT AND RETENTION OF FLEXIBILITY.

A Seminar Report

Presented to

the Faculty of the Department of Physical Education

Wisconsin State University at La Crosse

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Physical Education

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by

Richard Malstrom

August, 1969

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CHAPTER I

INTRODUCTION

Although flexibility is generally considered to be an important aspect of physical fitness, and a number of researchers have investigated means for attaining it, not much investigation has been made of the retention of flexibility once it has been attained. Also, there is conflicting evidence concerning the best means for attaining flexibility.

This researcher became very interested in the development and retention of flexibility through his experiences in coaching athletics and teaching physical education. A wide renge of joint motion is an important part of efficient physical education. This applies not only to the athlete but also to the individual whose physical performance plays an important role in his daily life. Even as a person grows older, flexibility is important, because, as the aging process proceeds, connective tissues tend to lose their elasticity, and this in turn may be related to the aches and pains of old age.[1] Maintaining a good range of movement at this age could be very beneficial.

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[1]Herbert A. De Vries, Physiology of Exercise for Physical Education and Athletics. (Dubuque, Iowa: Wm. C. Brown Company Publishers, 1966) p. 217.

Statement of the Problem

The problem was to determine the retention of flexibility after an organized program for the attainment of flexibility had been administered.

Purpose of the Study

The purpose of this study was to develop flexibility in the areas of the trunk and hips through the use of static and ballistic stretching techniques, and to determine whether or not one method is superior to the other in attainment and retention of flexibility.

Need for the Study

Flexibility is an important aspect in the overall physical conditioning of the individual. The role it has in athletic performance and the rehabilitation of the injured indicates its importance and need.

This study, by comparing the retention of flexibility developed in two different ways, could help improve physical education programs as far as the scheduling of activities is concerned.

The findings of this study could be an aid to developing adequate conditioning programs for athletics, physical education classes, adaptive physical education classes, and

corrective physical therapy programs.

Delimitations

This study involved sixty ninth grade boys at the Medford High School, Medford, Wisconsin.

Limitations

It was impossible to control the after school activities and the motivational attitudes the subjects had toward the study.

DEFINITIONS

Flexibility. Flexibility may be defined as the range of movement in a joint. This degree of movement depends on the flexibility and extensibility of the muscles and the ligaments surrounding the particular joint.[2]

Flexibility test. A flexibility test involves the measurement of the range of movement of a specific joint or articulation.

Goniometer. The goniometer is an instrument which is strapped onto a body part, and records in degrees, the range of motion of a specific joint or articulation or group of articulation.

Static stretching. Static stretching is stretching which involves a held position with no movement. The body segments which are to be stretched are locked into a position of greatest possible stretch.

Ballistic stretching. Ballistic stretching is that stretching involving quick movements. These movements are quick jerks and pulls upon the body segments to be stretched.

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[2]Harold M. Barrow, and Rosemary McGee, A Practical Approach to Physical Education (Philadelphia: Lea & Febeger Company, 1964), p. 119.

CHAPTER II

REVIEW OF RELATED LITERATURE

In recent years great interest has developed in physical fitness and overall conditioning. It is generally accepted that one of the important aspects of conditioning is flexibility.

Barrow and McGee stated that:

> Flexibility, like balance, plays its part in maintaining good posture and it is related to such components as endurance, speed, and agility.[3]

During the 1932 Olympics, the Japanese 880 yard relay team broke the then existing record by 38 seconds. In order to test the hypothesis that better speed and endurance swimming performances parallel greater flexibility in the major joints, the Japanese, American, and other relay teams were tested for their flexibility. It was shown that the Japanese team averaged 31.3% greater trunk flexion than the American team.[4]

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[3] Barrow, loc. cit.

[4] D. K. Mathews, V. Shaw, and M. Bohnen, "Hip Flexibility as Related to Length of Body Segments," Research Quarterly, 28: 352, December, 1957.

During the last three decades, the definition of flexibility has changed. In 1941, Cureton stated that flexibility means the capacity to bend, or to be flexed or extended without breaking. He also stated that each major joint has a high degree of specific flexibility of its own.[5]

Mathew, Shaw, and Bohnen, in 1957, stated that:

> Flexibility is most commonly defined as the range of joint motion. It must be recognized that such factors as muscle extensibility, joint structure, condition of ligaments, and fascia surrounding the joint, all in some manner affect the range of movement.[6]

In 1964, Barrow and McGee concluded that:

> Flexibility may be defined as the range of movement in a joint. It concerns degree of movement and limits the degree to which the body or body parts can bend or twist by means of flexion and extension of muscles. This degree of movement depends on the flexibility and extensibility of the muscles and ligaments surrounding the particular joint.[7]

They also related flexibility to proficiency in motor movement. It is significant in the performance of many

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[5]Thomas Cureton, "Flexibility as an Aspect of Physical Fitness," Supplement to the Research Quarterly 12: 381-382, 1941.

[6]Mathews, op. cit., p. 352.

[7]Barrow, loc. cit.

skills as a motor fitness factor.

Physical educators have been aware of flexibility as an asset to good performance in athletics. Larson and Yocum also lend support to the possibility of improved performance through increased body flexibility.

> The effectiveness of individual adjustments in many physical activities is determined by the degree of total body or specific joint flexibility. A highly flexible individual spends less energy in accomplishing skills than a less flexible individual, who, with greater expenditure of energy, may or may not make the necessary adjustments.[8]

C. L. Wear stated in his study that:

> Flexibility, depending on how it is measured, seems primarily to involve four factors: (a) bone structure, (b) tightness or loosmess of ligaments, (c) muscle strength, (d) muscle extensibility.[9]

Cureton concluded that the flexibility of specific joint areas can be determined by the ligament bindings, and if these bindings are loose and flimsy, the joint may be easily dislocated or strained.[10]

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[8]Leonard Larson and Rachael Donaven Yocum, Measurement & Evaluation in Physical, Health, and Recreation Education. (St. Louis, C. V. Mosby Co., 1951, p. 160.

[9]C. L. Wear, "Relationship of Flexibility Measurement to Length of Body Segments," Research Quarterly, 34: 234, May, 1963.

[10]Cureton, loc. cit.

Within the same joint, flexibility may vary from time to time depending on such factors as warm-up, temperature, effort, relaxation, and pain tolerance.[11]

There have been several ways of developing flexibility, all of which involve stretch. Two methods of attaining flexibility are static and ballistic stretching. Static stretching is that method which involves a held position with no movement. The body segments which are to be stretched are locked into a position of greatest possible stretch. Ballistic stretching is that method involving quick movements. These movements are quick jerks and pulls upon the body segments to be stretched. Such terms as spring stretch, fast stretch, and rebound stretch are all related to ballistic stretching.

Hupprich and Sigerseth stated:

> Flexibility is commonly spoken of as a general ability rather than a number of specific abilities, and the notion is still popular that young children are very flexible and that they become progressively less flexible as they become older.[12]

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[11] Barrow, loc. cit.

[12] F. L. Hupprich and P. O. Sigerseth, "The Specificity of Flexibility in Girls," Research Quarterly, 21: 25, March, 1950.

In their findings, it was shown that in nine of twelve measurements, girls increased in flexibility from six to twelve and then showed a decline.[13]

An increase in flexibility was noted in McCue's study in which she:

> ...administered five flexibility tests to college women and repeated them after three weeks of mild exercise. She found a significant increase in flexibility. Eight weeks after the completion of the exercise period, she found that three of the five movements studied remained at significant difference levels. Particular emphasis was placed on training each individual to make all movements in a relaxed rhythmic movement to the limit of her range of motion.[14]

In a recent study showing the effects of static stretching De Vries found that after unaccustomed exercise the static stretching technique seemed to provide some measure of prevention of ensuing muscular distress, such as shin splints in some athletes.[15]

In an unpublished study by Hilgendorf, pertaining to the retention of flexibility through static stretching

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[13]Ibid. p. 30.

[14]B. F. McCue, "Flexibility Measurement of College Women," Research Quarterly 24: 322, October, 1953.

[15]Herbert A. De Vries, "Electromyographic Observation of the Effects of Static Stretching Upon Muscular Distress," Research Quarterly 32: 479, December, 1961.

> The increased range is achieved by a series of jerks or pulls on the resistant muscle tissue. These jerks must be no greater than the extensibility of which the tissues are capable.[18]

Phillips, in administering Kraus-Weber tests to boys and girls from the ages of six to twelve, concluded that both sexes tend toward a rapid decrease in flexibility with increased age and the flexibility of the girls decreased more rapidly.[19]

Mathews, Shaw, and Bohnen, in their study on flexibility and its relationship between flexibility and body length.[20] Wear investigated the possibility that there might exist a certain relationship between measures of hip and trunk

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[18]G. T. Stafford and E. D. Kelly, Preventive and Corrective Physical Education (New York: Ronald Press Co., 1958), cited by H. A. DeVries, "Evaluation of Static Stretching Procedures for Improvement of Flexibility," Research Quarterly 33: 222-223, May, 1962.

[19]Marjorie Phillips, et al, "Analysis of Results from the Kraus-Weber Test of Minimum Muscular Fitness in Children, Research Quarterly 26: 321, 1955.

[20]Mathews, op. cit. p. 355.

flexibility and length of certain body segments. Out of the four major tests given, the sit and reach flexibility test was significantly related to excess of trunk and arm length over leg length.[21]

A basic measuring device - the gravity goniometer- was developed by Leighton. This type of instrument and the method in which it is used to measure flexibility is relatively free from any effects of variation in length of body segments. The goniometer is an instrument which is strapped onto a body part and records in degrees the range of motion of a specific joint or articulation or group of articulation. Leighton also reported the reliability of this measuring device as being above the .90 level.[22] In a related study by Hilgendorf, he reported a reliability coefficient of .90 for the trunk flexibility test, .973 for the hip flexibility test, and .942 for the trunk-hip flexibility test.[23] These particular tests and the measuring device used were also used for this research study.

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[21]Wear, op. cit., p. 238.

[22]Jack Leighton, "A Simple Objective and Reliable Measure of Flexibility," Research Quarterly 13: 215, May, 1942.

[23]Hilgendorf, op. cit., p. 15.

CHAPTER III

PROCEDURES

SELECTION OF SUBJECTS

The subjects selected were sixty freshmen boys from the Medford Senior High School, Medford, Wisconsin. The students names were listed alphabetically and a table of random numbers was used to divide them into three groups: Group A - control group, Group B - group working on static stretching techniques, and Group C - group working on ballistic stretching techniques.

SELECTION OF FLEXIBILITY TESTS

Jack R. Leighton designed the flexibility tests used within this study.[24] The areas of flexibility that were tested were the extension and flexion of the trunk and hips.

Hip Extension and Flexion Test. The subject assumes a standing position with his feet together, his knees straight,

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[24]Leighton, op. cit., p. 212.

and his hands clasped together behind his head. The goniometer is fastened to the individual at his hips on the right side at the height of the umbilicus. The subject, keeping legs straight, knees locked, feet flat on the floor, bends backwards as far as possible. At this point the goniometer was set to read zero. The subject then bent forward as far as possible and remained in this position until the second reading was taken. During the test the individual was not allowed to shift his feet, lift toes or heels from the ground, nor bend his knees.[25]

Trunk Hip Flexion and Extension Test. The procedure for this test is the same as is the hip flexion and extension tests. The only difference is that the instrument is placed to the right of the chest directly under the armpit at the height of the nipple.[26]

Trunk Extension and Flexion Test. To obtain the measure for the trunk extension and flexion tests one must subtract the measure for hip extension and flexion from the measure of trunk-hip extension and flexion test.[27]

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[25]Mathew, op. cit., p. 275.

[26]Ibid.

[27]Ibid.

ADMÆNISTRATION OF FLEXIBILITY TESTS

A pretest was administered to determine the flexibility of each individual before the program for the improvement of flexibility began. At the end of the training program the subjects were again tested to determine to what degree their flexibility had increased or decreased. The same test was given once a week for five weeks to assess the retention of flexibility. There were altogether six post tests.

GONIOMETER

The measuring device used in this experimental study was a mercury gravity controlled goniometer with adjustable dial, which was manufactured by Biggs Products of Oakland, California. The device was held to the body by means of an adjustable elastic belt.

TEST PROCEDURE

Before the testing began, the subjects were given an explanation and demonstration of all the tests to be given. At the time of the testing the students were dressed in their physical education uniforms. The subjects were not allowed to warm-up or perform any exercise or activity in

order to warm up the body. This was done so as to standardize testing procedures.[28]

When the students reported to the testing area, they came in groups of five, and the explanation and demonstration was presented to each group before the test was administered. This procedure was repeated for each of the seven testing periods. The tests administered were the Hip, Trunk-Hip, and Trunk Extension and Flexion Flexibility Tests.

If a subject was absent during a testing period, he was immediately tested the day he returned to class.

FLEXIBILITY PROGRAM

The subjects were divided into three groups - A, B, C - for the purpose of this study. Group A, the control group, was not involved in any flexibility program but did participate in regular physical education classes. Group B, the static stretching technique group, and Group C, the ballistic stretching technique group, were both involved in the flexibility program and also participated in the regular physical

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[28] Leighton, op. cit., p. 210.

education classes. The flexibility program lasted for four weeks with four classes a week.

The static and ballistic stretching exercises used in this study were selected from a previous study by H. A. De Vries.[29]

The static exercises in De Vries study were developed around the principles of Hatha Yoga, as described by Rele, and were designed to parallel the ballistic exercises in the particular joint areas.[30]

The ballistic stretching exercises were taken from Kiphuth's exercises for stretching swimmers.[31]

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[29]De Vries, op. cit. Research Quarterly 33: 224-225.

[30]V. G. Rele, Yogic Asanas for Health and Vigour. Bombay: D. B. Taraporevala Sons & Co. Private Ltd., 1958. cited by H. A. De Vries, "Evaluation of Static Stretching Procedures for Improvement of Flexibility," Research Quarterly 33: 224, May, 1962.

[31]R. J. H. Kiphuth, Swimming New York: A. S. Barnes and Co., 1942, cited by De Vries, Research Quarterly 33: 225 May, 1962.

De Vries study showed that the muscle groups that were the most difficult to improve were the lower back and ham strings, so in his program of static exercises the lower back stretcher was executed twice - once before the upper back stretcher and once immediately after it. He also did the same thing in his program of ballistic exercises. The trunk bender was executed twice, once before the upper back stretcher and once immediately after it. Two of the exercises from the static and ballistic stretching techniques were dropped from the program because they did not affect the extension and flexion of the back.

STATIC STRETCHING EXERCISES.

The following exercises were chosen for the static stretching program:

1. Upper Trunk Stretcher.

The performer assumes a front lying position, keeping his pelvis on the floor and legs straight. He then extends his arms straight and holds his head back.

2. Lower Trunk Stretcher.

The performer assumes a front lying position. He grasps his ankles from behind and pulls, so as to arch the back. Also the head is lifted off the floor and held in an extended position.

3. Lower Back Stretcher.

The performer assumes a sitting position with legs extended and toes pointed. He then grasps the outer borders of his feet and pulls his head downward.

4. Upper Back Stretcher.

The performer assumes a lying position on his back. He then raises his legs up and over his head, and rests his toes on the floor. While doing this his hands and arms are flat on the floor.

5. Gastrocnemius Stretcher.

The performer assumes a standing position three to four feet from the wall. He places hands on the wall and keeps body straight. He must keep feet parallel and flat on the floor.

6. Toe Pointer.

The performer sits on feet toes and ankles stretched backward. The knees are raised slightly off the floor, and balance weight slightly with both hands on floor just behind hips.

In the static stretching procedure each exercise involved a static holding position for a time limit of thirty seconds and each time the subject stretched towards his maximum level and held that position. The amount of time was increased by ten seconds each lesson until one minute was reached and then this time limit was maintained for

each exercise until the end of the program.

BALLISTIC STRETCHING EXERCISES

The following exercises were chosen for the ballistic stretching technique:

1. Trunk Lifter.

The performer assumes a front lying position with his hands behind his neck. He raises his head and chest vigorously, while a partner holds his feet.

2. Leg Lifter.

The performer assumes a front lying position with his arms down at his sides. He raises both his legs off the floor and lowers rapidly while a partner holds his back down.

3. Trunk Bender.

The performer assumes a sitting position with his legs apart and straight, and hands behind neck. He then bends trunk forward and downward in a bouncing fashion while keeping his back straight.

4. Upper Back Stretcher.

The performer assumes a sitting position with his legs crossed and hands behind his neck. He then tries to touch his head to the floor using a vigorous bouncing motion.

5. Trunk Rotation.

The performer is in a standing position with his arms extended laterally. He then twists to the left and to the right.

6. Gastrocnemius Stretcher.

The performer stands on a board with the balls of his feet. He then lowers weight and returns rapidly, and may use a partner to balance if necessary.

In the ballistic stretching procedures each exercise was performed at twenty repetitions, and worked up to forty repititions by the fourth workout.

CHAPTER IV

STATISTICAL PROCEDURES

The design for the investigation was a two factor experiment. The two variables were the attainment of flexibility and then the retention of flexibility. The pre training test and a series of post training tests resulted in repeated flexibility measures for each subject.

The analysis of variance technique was applied to the data. The experimental design and the analysis of variance procedures as explained by Winer were implemented and executed by use of an IBM 1130 computer.[32]

Three hypothesis were tested. These were:

1. There is no difference in the degree of flexibility attained by ballistic training techniques and training methods.
2. There is no change in flexibility from pre test to final post test.
3. There is no difference in attained and retained flexibility due to interaction of methods and tests.

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[32]B. J. Winer, Statistical Principles in Experimental Design. New York: McGraw Hill Book Company, 1962. p. 298-312.

The five percent level of confidence was selected as the criterian for rejection of the null hypothesis.

STATISTICAL ANALYSIS

The design for the investigation was a two factor experiment with repeated measures on one factor. The analysis of variance technique was used to analyze the data.

Hips. Table I, page 24, summarizes the analysis of variance for the hip flexion and extension test scores.

The F ratio for differences in hip flexibility due to method was .461. This value did not exceed the critical F value of 3.15, and therefore the null hypothesis that over the course of the experiment there was no difference in attained flexibility due to method was accepted.

The hypothesis that there was no significant difference among the combined means for alll groups for the tests of hip flexibility was rejected, because the attained F value of 4.828 was significant. The F ratio does not indicate which means were significantly different from each other. It did indicate that further statistical tests were necessary.

The significant F value of 4.706 indicated that interaction between methods and tests was present. Therefore, further analysis was made in terms of simple main effects,

TABLE I

ANALYSIS OF VARIANCE SUMMARY

HIPS

Source of variation	S. S.	df	M. S.	Critical F value	F
Between subjects	69900.016	59			
Methods	1113.000	2	556.50	3.15	.461
Subjects within groups	68787.016	57	1206.79		
Within subjects	46686.508	360			
Between tests	3164.501	6	527.42	2.10	4.820
Interaction	6168.000	12	514.00	1.75	4.706
Between tests X subjects within groups	37354.008	342	109.22		

and F values associated with these effects were computed.

An obtained F ratio of 4.37 indicated that the effects of method were significantly different at post test five. The Newman Kuels procedure was used to test the difference between the mean scores of each group (control, static, ballistic) on post test five. Hip flexibility of the statically trained group was significantly greater than that of the ballistically trained group. Hip flexibility of the ballistically trained group was significantly greater than that of the control group. Table II, page 26, graphically compares the mean hip flexibility of each group for each test.

Since significant F values of 5.30, 5.64, 3.30, indicated that there were differences between test means within the control, static, and ballistic groups, the Newman Kuels procedure, as shown by Winer, was used to determine which of the test results were significantly different.[33] The Newman Kuels procedure indicated that for the control group the hip flexibility was significantly greater at post test six than at any other point. The lowest flexibility test scores were made on post tests three and five, and these

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[33]Ibid.

TABLE II

F Ratios Indicating Difference
Between Hip Flexibility Means
(Between Groups)

	Control	Static	Ballistic	F Score
Pre test	69.10	63.55	69.80	.882
Post test 1	68.05	77.30	79.65	2.827
2	69.95	77.60	78.40	1.636
3	66.20	74.10	73.30	1.422
4	76.00	76.25	74.00	.114
5	63.25	78.50	70.60	4.373*
6	78.55	68.80	68.60	2.432

* Denotes an F score that is significant at the .05 level of confidence.

tests results were not significantly different from each other.

For the static group there was a significant increase in hip flexibility immediately after training, as indicated by a comparison of the pre test results and post test one. Tests one through five were not significantly different from each other. Post test six was significantly lower than all the preceeding post tests, indicating that flexibility was lost at this point.

The highest hip flexibility scores for the ballistic group were achieved on post tests one and two, and these scores were not significantly different from each other, but were significantly different from all other scores. The lowest test scores were obtained from the pre test and from post tests three, five, and six. These scores were not significantly different from each other, but were significantly lower than all other scores.

Trunk-Hips. Table III, page 28, shows the analysis of variance for the trunk-hip flexion and extension test scores. The F ratio for differences in trunk-hip flexibility due to method was 3.14. This value does not exceed the critical F value of 3,15, and therefore the null hypothesis that over the course of the experiment there was no difference in attained flexibility due to method was accepted.

The hypothesis that there was no change in flexibility

TABLE III

ANALYSIS OF VARIANCE SUMMARY

TRUNK-HIPS

Source of Variation	S. S.	df	M. S.	Critical F Value	F
Between Subjects	94346.016	59			
Methods	9362.002	2	4681.001	3.15	3.139
Subjects within groups	84984.016	57	1490.947		
Within Subjects	57298.008	360			
Between Tests	5410.00	6	901.667	2.10	6.7929
Interaction	6492.00	12	541.00	1.75	4.0757
Between Tests X Subjects within Groups	45396.007	342	132.737		

from test to test was rejected because the F value of 6.79 was significant. This F value did not indicate which means were sigmificantly different from each other. It did indicate that further statistical tests were necessary.

The value of F for the interaction between methods and tests was 4.07. Because of the significant value of F, further analysis was made in terms of simple main effects.

The obtained F values for post tests one, two, three, and five were 4.64, 4.83, 8.86, and 5.10 (Table IV, page 30). These values indicated that the effects of methods were significantly different at each of the four post tests. The Newman Kuels method was then used to test the differences in mean scores of each group at each of the four post tests.

In post tests one, two, and three both the static and ballistic trunk-hip flexibility groups had significantly greater flexibility than the control group, but were not significantly different from each other. Post test five indicated that the trunk-hip flexibility of the statically trained group was significantly greater than that of the ballistically trained group. Trunk-hip flexibility of the ballistically trained group was significantly greater than that of the control group.

The significant F values of 5.85, 6.26, and 2.87 indicated that there was a difference between test means within the control, static, and ballistic groups. The Newman Kuels

TABLE IV

F Ratios Indicating Difference
Between Trunk-Hip Flexibility Means
(Between Groups)

	Control	Static	Ballistic	F Score
Pre test	159.65	156.70	161.75	.394
Post test 1	161.55	176.85	176.60	4.637*
2	153.00	168.65	168.10	4.827*
3	139.70	170.25	168.75	8.861*
4	166.00	165.25	168.55	.183
5	155.50	173.50	167.15	5.100*
6	164.00	167.75	167.30	.260

*Denotes an F score that is significant at the .05 level of confidence.

method was used to determine which of the test means results were different.

For the control group the Newman Kuels procedure showed that trunk-hip flexibility was significantly greater at post tests one, four, and six than for any of the other tests, and these scores were not significantly different from each other. The lowest flexibility test score was post test three. The results of the pre test and post tests two and five, were not significantly different from each other.

For the trunk-hip flexibility of the ballistic group, post tests one and three were significantly greater than all other scores but were not significantly different from ecah other. The lowest test was the pre test which was significantly different from all other scores. Post tests two, four, five, and six were not significantly different from each other.

For the statically trained group, the highest test scores were achieved on post tests one and five. These scores were significantly different from each other. The pre test was the lowest score and was significantly different from all other scores. Post test two, three, four, and six were not significantly different from each other.

Trunk. Table V, page 32, summarized the trunk flexibility by analysis of variance.

The F ratio for differences in trunk flexibility due

TABLE V

ANALYSIS OF VARIANCE SUMMARY

TRUNK

Source of Variation	S. S.	df	M. S.	Critical F Value	F
Between Subjects	34913.508	59			
Methods	4243.500	2	2121.750	3.15	3.943
Subjects within groups	30670.00	57	538.070		
Within Subjects	52752.508	360			
Between Tests	3042.500	6	507.083	2.10	3.645
Interaction	2132.00	12	177.666	1.75	1.277
Between Tests X Subjects within Groups	47578.008	342	139.117		

to method was 3.943. The value exceeded the critical F value of 3.15, and therefore the null hypothesis that over the course of the experiment there was no difference in attained flexibility due to methods was rejected.

The Newman Kuels procedure was used in determining this difference, and it was found that the statically trained group and the ballistically trained group were both significantly greater in trunk flexibility than the control group but were not significantly different from each other.

The hypothesis that there was no difference among the means of the trunk flexibility measures of the static, ballistic, and control groups was rejected because the F value of 3.645 showed a significant difference. To show the difference among the means of the trunk flexibility the Newman Kuels procedure was used to check the means of the tests of trunk flexibility.

The results of the comparison of the means of the tests of trunk flexion and extension showed that post tests one, five, and six were not significantly different from each other, but all were significantly greater than post test two. The means of pre test, tests two, three, four were not significantly different from each other. Also, pre test, tests one, three, four, five, and six were not sigmificantly different from each other.

There was not a significant F value for the interaction between methods and tests.

TABLE VI

F Ratios Indicating Difference

Between Trunk Flexibility Means

(Between Groups)

	Control	Static	Ballistic	F Score
Pre test	90.50	93.65	92.05	.253
Post test 1	93.55	99.50	96.95	.908
2	83.05	91.05	89.70	1.870
3	82.50	96.15	95.35	5.984
4	89.50	89.35	94.55	.893
5	92.00	95.75	96.55	.602
6	85.85	99.00	98.70	5.747

CHAPTER V

SUMMARY

A group of sixty high school freshmen boys from Medford High School, Medford, Wisconsin were the subjects for this study of the attainment and retention of trunk-hip flexibility.

The subjects were divided into three groups by random selection. Group A was a control group and did not participate in the flexibility improvement program. Group B, the static group, performed static stretching exercises. Group C, the ballistic group, performed ballistic stretching exercises. A pre test for trunk-hip flexibility was administered to each group. The flexibility development program of four weeks duration (four times a week) was conducted, and then six post tests were taken. There was a lapse of one week between each post test.

The design of the study was a two factor experiment. The analysis of variance technique was applied to the data.

Three hypothesis were tested.

(1) There is no difference in the degree of flexibility attained by static and ballistic training techniques.

(a) Hips; The hypothesis was accepter because the F ratio was not significant.

(b) Trunk-Hips: The hypothesis was accepted because the F ratio was not significant.

(c) Trunk: The F ratio of 3.49 was significant and therefore the null hypothesis was rejected.

(2) There is no change in flexibility from pre test to final post test.

(a) Hips: The F ratio of 4.83 was significant and therefore the null hypothesis was rejected.

(b) Trunk-Hips: The F ratio of 6.79 was significant and therefore the null hypothesis was rejected.

(c) Trunk: The F ratio of 3.64 was significant and therefore the null hypothesis was rejected.

(3) There is no difference in attained and retained flexibility due to interaction of methods and tests.

(a) Hips: The F ratio of 4.70 was significant and therefore the null hypothesis was rejected.

(b) Trunk-Hips: The F ratio of 4.07 was significant and therefore the null hypothesis was rejected.

(c) Trunk: The F ratio of 1.27 was not significant and therefore the null hypothesis was accepted.

CONCLUSIONS

From the findings of this study one could conclude that:

(1) Both the static and ballistic stretching techniques are apparently equally effective in attaining the flexibility of the trunk and hips.

(2) However, flexibility of the trunk and hips attained through the static stretching technique is attained longer.

Because there was interaction between tests and methods this author was forced to conclude that there were uncontrolled variables operating during this investigation. From the evidence of the data, it would seem that learning may have been one of the factors --- motivation could have been another.

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