THE RELATIONSHIP OF STRENGTH AND FLEXIBILITY TO TUMBLING SKILL ACHIEVEMENT

A Thesis

Presented to

the Faculty of the College of Education

University of Houston

In Partial Fulfillment

of the Requirements for the Degree

Master of Education

---

by

Thomas John Donovan III

December 1972

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ABSTRACT

THE PROBLEM

The problem of this study was to test the research hypothesis of Fleishman that basic abilities are related to achievement of skill development. An answer was sought to the question: Are basic abilities of static strength, dynamic strength, extent flexibility, and dynamic flexibility related to achievement of basic tumbling skills?

Delimitations. The study was delimited to four sections of male undergraduate students enrolled in gymnastics classes in the basic instruction program of physical education at the University of Houston. The study was further delimited to static and dynamic strength items utilizing arm strength and to extent and dynamic flexibility items utilizing the entire body. Additional delimitations of the study were the fifty-two basic tumbling stunts and two tumbling routines composed of basic tumbling stunts. All stunts presented were suitable for beginning learners and recognized by the International Gymnastics Federation.

Data Collection. There was a total of seventy subjects tested on the independent and dependent variables during a six week period.

Twenty-eight subjects met two times per week for one and one-half hours per class, while forty-two subjects met three times per week for one hour per class.

Analysis of Data. The intraclass reliability estimates for the selected tests were computed. The data were tested for random selection from the observed population by means of the t-test. The data for the dependent variable were not found to be normally distributed and were converted to t-scores using the percentile rank transformation method.

The independent variables were obtained from a general incomplete principle components analysis program. The desired orthogonal solutions were obtained by the Kaiser varimax rotation procedure. The data were further analyzed using the BMD02R stepwise regression analysis to determine the relationship of the independent variables to tumbling skill achievement.

Summary of Findings. The following findings were reported: (1) Dynamic strength and flexibility, particularly of the dynamic type, were significantly related to tumbling skill achievement; and (2) extent flexibility and static strength were unimportant for determining tumbling skill achievement.

Conclusions. The research hypothesis that basic abilities are related to skill achievement was confirmed. The basic abilities of strength and flexibility are related to tumbling skill achievement.

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Chapter 1

INTRODUCTION

Research in physical education has been conducted in order to determine what motor abilities compose the underlying basis for the successful completion of gross psychomotor skills.(6, 34, 36) These attempts have been expanded to encompass many activities in which students participate. (40) Gymnastics and tumbling have received little attention by researchers. There are very little data regarding gymnastics and tumbling which concerns psychomotor factors needed to perform basic skills in a physical education class or in competition.

To determine these psychomotor factors, research is needed to identify the basic abilities that compose gymnastics and tumbling skills. Basic motor abilities are innate in all students in varying degrees. These basic abilities and the extent to which they may be developed need to be recognized by instructors to facilitate successful teaching. (8:168) The terms "skill" and "ability" must be clearly understood if one is to understand their relationship. Fleishman (15:9) has defined ability as "a more general trait of the individual which has been inferred from certain response consistencies (e.g. correlations) on certain kinds of tasks." This term has been further defined to mean "a basic factor of motor behavior which

underlies a number of more complex skills." (3:168) Barrow (3) states that general abilities are universal in nature, thus giving credence to the premise that abilities are the chief underlying factors needed for skill acquisition. The term skill refers to the level of proficiency on a specific task or limited group of tasks. (15:9) In using the term skill, one implies that a learning experience has taken place and that a change in behavior has resulted. (3:169) According to Fleishman (15:10), "skills involved in complex activities can be described in terms of more basic abilities." Using this premise, individual differences in the complex activity of tumbling can be described in terms of more basic abilities such as strength, flexibility, agility, balance, coordination, and speed of limb movement. "The individual who has a great many highly developed basic abilities can become proficient at a great variety of specific tasks." (15:10) Cratty (11:228) stated that "ability is a basic facet of motor behavior which underlies a number of more complex skills."

One must recognize the specificity theory of motor performance. (22) The desirable approach is to measure all specifics which compose a motor skill, but this approach is not realistic. The traditional approach has been to sample the specific abilities underlying successful performances and correlate these few with the composite of many specifics which served as a motor ability criterion. (8) Henry (21) has noted that general motor ability can be represented by the sample of specifics

selected. Early research produced evidence that general performance characteristics did exist; however, later research indicated the specific nature of motor skills. Henry (11, 21) reported that tasks which involved movement, speed, reaction time, and strength were based upon factors specific in nature. A problem generally associated with motor ability testing is that general motor ability is a single trait that is important to all skills. This is not the case as one can logically see, e.g. running speed is not important to tumbling skill. The major problem is that of determining what basic abilities are related to specific skills. "The abundance of research attempting to find relationships between achievement in motor skills has tended to indicate the specificity of task performance. There are many motor abilities, each specific to the situation in which it is applied." (11:127)

Statement of the Problem

The problem of this study was to test the research hypothesis of Fleishman (15), that basic abilities are related to achievement of skill development. An answer was sought to the question: Are basic abilities of static strength, dynamic strength, extent flexibility, and dynamic flexibility related to achievement of basic tumbling skills?

Need for the Study

The components of basic tumbling abilities have not been thoroughly investigated. In the past it was assumed that the development of certain psychomotor factors were needed, but the knowledge as to which were most important was not determined. Early studies selected areas deemed important by the coach and tested only those. (58) The purpose of this study was to determine the relationship of strength and flexibility to the successful achievement of basic tumbling skills. If the achievement of basic tumbling skills is related to the fundamental components of strength and flexibility, it may be assumed that through the development of these factors the student may achieve a level of competence in these motor skills.

The identification of basic abilities related to skill achievement is useful for individualizing instruction. Grouping according to existing abilities can aid in the 1) placement of students, 2) diagnosis of deficiencies, 3) assessment of performance, 4) prediction of future performance, and 5) evaluation of performance achieved in class. (14) This grouping can aid in the organization of the class and enable the students to practice without excessive peer group harrassment and thereby facilitates individualized instruction.

Basic Procedures of the Study

The following procedures were used in conducting this study:

1. A MEDLINE (MEDLARS-on-line) search was conducted to determine if there was a need for this type of study. (61)

2. Literature pertaining to the relationship of basic abilities to skill achievement was reviewed.

3. Basic abilities of strength and flexibility were logically selected to be tested and tests were obtained through a review of literature.

4. A pilot study was conducted to test the procedures to be used and feasibility of administering the tests selected.

5. Subjects were obtained for the study and the necessary equipment needed to conduct the study was prepared.

6. The dependent and independent variables were administered during a six week period and the data collected, reported, analyzed, interpreted, and the findings and conclusions were drawn.

7. Separate samples of subjects were used to replicate the study and test the research hypothesis. Subjects for this study were selected from classes which met either two times per week for one and one-half hours per class or three times per week for one hour per class.

Delimitations of the Study

The study was delimited to four sections of male undergraduate students enrolled in gymnastics classes in the basic instruction program of physical education at the University of Houston. The study was further delimited to static and dynamic strength items utilizing arm strength and to extent and dynamic flexibility items utilizing the entire body. Additional delimitations of the study were the fifty-two basic tumbling stunts presented and two tumbling routines composed of basic tumbling stunts. All stunts presented were suitable for a beginning learner and recognized by the International Gymnastics Federation.

Limitations of the Study

The subjects used in this study were not randomly selected from the total male undergraduate population enrolled in the basic instruction classes in physical education at the University of Houston for the Spring semester of the school year 1971-1972. Instead, a cluster sample of subjects was selected. It has been reported that if the cluster sample consists of a heterogenous group, then the difference between the estimated standard errors of a random sample and a cluster sample is small. (12)

In order to obtain sufficient subjects, all students who were enrolled in basic gymnastics and who completed all test variables were

included in this study. The four classes were divided into two samples. Two classes met three times per week for one hour and two classes met two times per week for one and one-half hours per class. This allowed two separate analyses to test the research hypothesis of this study. Forty-two subjects met three times per week and twenty-eight subjects met two times per week.

The study was further limited to four factors of basic ability: 1) static strength, 2) dynamic strength, 3) extent flexibility, and 4) dynamic flexibility. Generalizations cannot be made to other basic abilities which may be related to tumbling skill achievement for the population studied.

Due to the unavailability of judges meeting the criteria of knowledge and experience in gymnastics, the investigator served as the sole judge for all evaluations in the tumbling and routine testing. Criteria supporting the investigator's qualifications to serve in this capacity were: 1) a judge of gymnastic competition at all levels of difficulty, 2) a competitor in intercollegiate gymnastics, 3) an assistant gymnastics coach, and 4) thirteen years of experience in gymnastics.

Definition of Terms

For the purpose of this study the following terms were defined:

Dynamic strength: involved "the strength of muscles in the limbs moving

or supporting the weight of the body repeatedly over a given period of time." (15:30) According to Fleishman (15), the best tests of this factor were pull-ups, rope climb, and dips.

> A critical aspect of this factor appears to be the requirement that the muscular force must be repeated as many times as possible with a consequent progressive decrement in the force which can be exerted. Individual differences in this ability are largely a function of how many repetitions can be made. (15:72)

Static strength: This factor is defined as "an exertion of a maximum force for a brief period of time where the force was exerted continuously up to a maximum." (15:69) This factor was contrasted with dynamic strength in that it did not involve substantial movement of the body and the force was not repeated in successive movements. A grip dynamometer was used to measure this factor.

Extent flexibility: "This refers to the ability to extend or stretch the body, or some part thereof, as far as possible in various directions." (15:79) Examples of common tests used to measure this factor were: 1) the modified sit and reach test as cited by Wells and Dillon (57), and 2) the simple bridge-up as described by Johnson and Nelson. (27)

Dynamic flexibility: "This refers to the ability to make repeated, rapid movements which involve muscle flexibility." (15:78) This factor has been called Flexibility-Speed due to the fact that tests revealed a cluster of factors which emphasize both flexibility and speed. (15:78) Investigations by Fleishman (15) and others have revealed that there may be

subfactors associated with this ability. The subfactors mentioned were: 1) speed of change of direction, sometimes referred to as agility, which emphasizes the ability to change direction of the body or body parts either abruptly or in a continuous manner; 2) running speed as measured by short and long dashes; and 3) speed of limb movement as represented by the ability to move the arms or legs as rapidly as possible with no skill involved. The tests used in this study were: 1) the bend, twist, and touch test as mentioned by Fleishman (15), and 2) a test to measure shoulder girdle flexibility which was introduced by the investigator.

Organization of the Report of the Study

This study was organized as follows:

Chapter 1 includes an introduction to the problem, statement of the problem, need for the study, basic procedures of the study, delimitations of the study, limitations of the study, definition of terms, and organization of the report.

Chapter 2 presents a survey of related literature. This chapter is divided into sections dealing with the relationship of general factors to gymnastics and tumbling and measurement of basic abilities.

Chapter 3 contains the procedures used in the study. This chapter includes a description of equipment used in the study, subjects, independent variables, dependent variables, and statistical procedures.

Chapter 4 contains the descriptive statistics, factor analysis of the independent variables, the relationship between basic abilities and the tumbling achievement, and summary of the statistical findings.

Chapter 5 includes the summary, findings, discussion of findings, conclusions, and recommendations for further study.

Chapter 2

REVIEW OF LITERATURE

This study tested the research hypothesis that the basic abilities of strength and flexibility were related to the achievement of basic tumbling skill. The independent variables of this study were the factor scores obtained by tests of dynamic strength, static strength, extent flexibility, and dynamic flexibility. The dependent variable was the achievement of selected stunts during six weeks of tumbling instruction. There were seventy male undergraduate college subjects used in this study. The research hypothesis was tested with two separate analyses in which sample one was composed of forty-two subjects, while the second sample was composed of twenty-eight subjects.

In order to provide an adequate base for the study, the following areas were selected for review:

1. General factors related to gymnastics and tumbling
2. Measurement of basic abilities.

Relationship of General Factors to Gymnastics and Tumbling

The majority of literature dealing with gymnastics and tumbling skills deals primarily with mechanical analyses. The purpose of this study

was to determine to what extent the basic abilities of strength (dynamic and static) and flexibility (dynamic and extent) were related to the successful completion of basic tumbling stunts. A MEDLINE search was conducted for literature in this area, but failed to reveal any pertinent studies related to this investigation.

The first attempt to design tests for predicting potential ability in gymnastics and tumbling was conducted by Wettstone (58) in 1938. A series of ten tests which measured the psychomotor and affective qualities that gymnastics coaches felt were essential to successful gymnastics performance were administered to twenty-two gymnasts from the University of Iowa. From the collected data, a regression equation was computed composed of three predictor variables: 1) thigh circumference divided by height, 2) strength tests consisting of chins, dips, and thigh flexion, and 3) the Burpee test. The multiple correlation between these predictor variables and the criterion of successful gymnastics performance was reported as .79.

In 1970, Regna (46) utilized a five item test consisting of balance and strength skills to predict potential gymnastics ability. Students were pretested on their ability in these five items and then retested after completing fourteen classes of instruction in gymnastics. The multiple correlation reported in this study between the two trials of strength and balance items and gymnastics potential was .70.

Various studies have examined the effect of gymnastics or tumbling on the development of physical fitness. Wilbur (60) compared the sports method versus the apparatus method in predicting physical fitness. Apparatus method was defined as a formalized program that consisted of work on the parallel bars, tumbling mats, climbing rope, horizontal bar, Swedish vaulting box, side horse, and rings. Sports method referred to a program of instruction and participation in boxing, wrestling, track and field, soccer, and swimming. Although the sports method was superior in overall development of physical fitness, the apparatus method was superior in the development of speed of leg movement, leg strength, arm and shoulder girdle strength, body control, coordination, and agility.

Landiss (33) investigated eight physical education activities to determine the development of physical fitness and motor ability for freshman college males participating in the selected activities. The activities studied were beginning courses in swimming, boxing, weight training, tennis, wrestling, volleyball, tumbling-gymnastics, and basic conditioning. The Larson test of motor ability was used to establish the criterion of motor ability. The test used to measure physical fitness was a modification of the Army-Air Force PFT. From the collected data, Landiss concluded that physical fitness was improved in those students participating in conditioning and tumbling-gymnastics. Those students engaged in wrestling and tumbling-gymnastics made significant gains in motor ability.

The tumbling-gymnastics group was the only one that demonstrated a significant improvement on each item of the physical fitness test.

A study by Musker, Casady, and Irwin (43) compared the physical fitness values of gymnastics with those derived from track and field, winter sports, combatives, swimming, team games, weight lifting, and dancing. The scores received on each of the activities were reviewed by a panel of experts and the results showed that gymnastics ranked the highest of the selected activities in developing physical fitness.

The majority of research that was reviewed indicated the value of gymnastics and tumbling in developing physical fitness, but did not establish what were the underlying abilities that composed successful gymnastics and tumbling achievement. Hence, the review of literature was expanded to determine what abilities were the foundation for physical fitness and, therefore, gymnastics and tumbling.

Measurement of Basic Abilities

Early studies by McCloy (39) listed ten factors as prerequisites to learning motor skills. The factors were: muscular strength, dynamic energy, ability to change direction, flexibility, agility, peripherial vision, good vision, concentration, understanding of the mechanics of the techniques of the activities, and absence of disturbing or inhibiting emotional complications. McCloy (38) also designed a test to determine the general motor ability of a student.

Fleishman (15) has completed the most comprehensive investigation of the components related to physical fitness. Ability was defined by Fleishman as a "general trait of the individual which has been inferred from certain response consistencies (e.g. correlations) on certain kinds of tasks." (15:7) These traits were fairly enduring and actually formed the basis for future performance. Ability was found to be related to performance in a number of tasks. An individual who had a varied background of abilities was able to achieve a greater skill acquisition. The term skill referred to the level of proficiency on a specific task or limited group of tasks. (15:9) According to Fleishman, "the distinction between abilities and skills allows us greater precision in describing, understanding, and predicting many complex human performances." (15:26)

Basic abilities are acquired early in life. The environment, cultural setting, motivational factors, and maturation level of a child had great importance in the development of basic abilities. Bodily growth had great significance in determining one's ability in certain areas. In an examination of the anatomical make-up of gymnasts, it was reported that gymnasts had shorter legs and arms, narrower hips, and were shorter in height when compared to the average college athlete. However, their arm circumference was larger and their legs were stronger in addition to having greater explosive power. (45)

Abilities that were developed as a child were carried over into

adult life due to the fact that these abilities were actually overlearned. (15:12) As a result these abilities were able to be retained until late in adult life with appropriate practice. In reference to skill acquisition, the rate of learning and final level of competency achieved were dependent upon the basic abilities that were developed. Therefore, through the development of basic abilities, there could be greater skill acquisition as well as an increase in the level of proficiency of certain skills. Through the process of ability differentiation, the process of increasing distinctiveness of basic abilities, it was possible to make precise predictions of how individuals would differ in their performance of a variety of specific tasks. (15:15) This concept formed the research hypothesis of Fleishman's investigation of the abilities affecting physical fitness.

Fleishman organized broad ability areas into factors present in physical fitness. Strength was the area with the greatest amount of work reported. Included in the strength were three broad factors as determined by existing tests of strength. The three factors were: (1) explosive strength, (2) dynamic strength, and (3) static strength. Explosive strength tests required the subject to jump, or to project himself or an object, as far or as high as possible. Tests of this factor included running tests as well as the standing broad jump, vertical jump, softball throw and others. The factor dynamic strength required the muscular force to be repeated as many times as possible with a progressive decrease in the force exerted. Common tests which measured this factor were:

(1) pull-ups to the limit, (2) dips to the limit, and (3) rope climb in six seconds. The best measure of this factor was the tests which required the arms to move or support the body weight either repeatedly or continuously. The factor static strength required an exertion of maximum force for a brief period of time where the force was exerted continuously up to a maximum. This factor revealed that height and weight were positively related to static strength, but were negatively related to dynamic strength. Tests used to measure static strength included all those involving dynamometers or weights. The most important finding was the generality of static strength to different muscle groups and to different tasks.(15:72)

The flexibility factor was determined to be composed of extent flexibility and dynamic flexibility subfactors. Extent flexibility was characterized by the ability to flex or stretch the trunk and back muscles as far as possible in either a forward or backward direction. It was best measured by tests which involved abdominal stretching, and twisting and touching. Dynamic flexibility involved the ability to make repeated, rapid, flexing movements. A critical factor in this ability was the resiliency of the muscles in recovering from strain or distortion due to speed of the repeated movements involved. The best measure of this factor included the lateral bend; squat, twist, and touch; and the bend, twist, and touch test. (15:31)

The balance factor has not been well defined since most studies have used only one or two tests of this factor. Fleishman used

eight tests of static balance, two tests for performance or dynamic balance, and two tests for balancing objects. The tests which were used required that the eyes be both opened and closed since vision was related to this factor. The static balance factor represented the ability to maintain bodily position in fixed equilibrium. Tests of dynamic balance required the subject to maintain his balance while performing a specific task. The object balancing factor required the individual to balance objects with his hands or fingers while standing still (15:33)

Coordination was a factor separate from strength, flexibility, speed, and balance. Subfactors of multi-limb and gross body coordination have been reported, but were poorly defined. Fleishman's findings suggested that the multi-limb coordination factor depended on central or cortical nervous system activity. The gross body coordination factor emphasized central nervous system factors which were independent of body members or particular muscle groups. It was therefore not possible to develop a test which solely tested this factor. Fleishman theorized that the coordination factor was actually the ability to integrate the separate abilities in a complex task. (15:34)

The problems associated with coordination testing were that the factors tested represented a multi-dimensional aspect of physical fitness. Fleishman (15) was able to explain performance in sixty different physical fitness tests in terms of the investigated factors. He was also able to

specify which tests provided the best measures of each factor.

Further investigations of the factor structure of flexibility were conducted by Harris. (20) Single joint action and composite actions were measured to test the flexibility of 147 college women. There were fifty-three variables (38 joint action, 13 composite, and two anthropometric measures) included in the final analysis. There were fourteen common factors judged to be comparable over all nine of the derived solutions. The major conclusions of the study were that there was no evidence that flexibility existed as a single general characteristic of the human body and that no one composite test or no one joint action measure could give a satisfactory indication of the flexibility characteristics of an individual. According to Harris, flexibility was structured according to the body segment being used.

In a refinement of Fleishman's work, Liba (35) conducted a factor analysis of strength variables to test a hypothesized factor structure for a number of test variables which have been used to assess strength. It was reported that different factor analysis models yielded different numbers of factor and that the factor structure yielded by one analysis did not coincide with that yielded by another analysis. The factor identified as explosive strength required more investigation due to the fact that the variables which were labeled "body projection tests" represented a complex of abilities and not a single factor. The hypothesized factor

structure for holding, pushing, and pulling the body weight against gravity warranted further investigation due to the fact that arm support on the parallel bars was a distinct factor from the other items in the same group. Liba theorized that since it was the only item which required the body to be stationary and supported by the arms in an extended position, it may have represented an ability other than that represented by pull-ups or the bent arm hang. Further results did not support the findings of previous studies dealing with the factor static strength. The results suggested a more specific structure for static strength as three factors were needed to represent the five item test used in the study. It was further suggested that additional study was needed to clarify the relationship of the factors investigated.

Jackson (26) investigated Fleishman's three factor strength model of explosive strength, dynamic strength, and static strength. The study was in agreement with Liba (35) that additional strength abilities exist. Fleishman's factor of static strength was confirmed, but the factor of explosive strength was found to be composed of several factors.

Larson (34) factor analyzed twenty-five motor ability items in the development of an indoor and an outdoor test for general motor ability. The indoor test was composed of the dodging run, bar snap, chinning, dips, and the vertical jump. The outdoor test consisted of tests in chinning, the bar snap, vertical jump, and the softball throw for distance.

According to Larson, the tests did not predict nor indicate specific qualities such as agility or endurance; but they did indicate the ability in the basic elements underlying sports skills.

Summary

The previous studies cited indicate that basic abilities are present in certain activities. However, little research has been reported pertaining to the relationship of basic abilities to skill achievement. The factors of strength and flexibility were composed of subfactors which determined the extent of their usefulness in the acquisition of basic skills. Since tumbling is a complex psychomotor skill, the development of the underlying factors could facilitate successful performance, particularly as tumbling has been shown to be related to fitness producing activities.

Chapter 3

PROCEDURES

The procedures included in this chapter were utilized in an attempt to insure uniform data collection and to allow for replication. The procedures permit replicated analyses to test the research hypothesis that the basic abilities of strength and flexibility were related to tumbling skill achievement.

Subjects

Subjects used in this study were students who were enrolled in the basic instruction classes of physical education who had selected gymnastics and tumbling as their activity for the Spring semester 1972. There were two samples used to test the research hypothesis that strength and flexibility were related to achievement of basic tumbling skill. In the first sample, forty-two of the subjects were enrolled in classes meeting three times per week for one hour per class. The second sample consisted of twenty-eight subjects who met two times per week for one and one-half hours per class. All subjects were tested during the first six weeks of the semester.

Independent Variables

The independent variables consisted of the factor scores obtained through factor analysis of the eight tests selected to measure the basic abilities of dynamic strength, static strength, dynamic flexibility, and extent flexibility.

Construct validity of the independent variables was insured through the review of literature and the selection of reliable tests designed to measure the factors sought in this study. Construct validity is an index of how well a test measured a particular basic ability that the author wished to measure. (15:134)

Dynamic strength: The tests selected to measure dynamic strength for this study were (1) pull-ups to exhaustion, and (2) parallel bar dips to exhaustion. The pull-up and the dip tests were selected to measure the subject's ability to move his body weight as required in tumbling. These tests as reported by Fleishman (15:64) have high factor loadings on the dynamic strength factor (i.e. pull-ups = .81; dips = .63). The best measures of dynamic strength were reported to be tests in which the arms were required to move or support the weight of the body repeatedly or continuously. The pull-up test had reliability coefficients reported with college men as high as .99, while the dip test had reliability coefficients as high as .98 reported with college men. (27:243)

Directions used in the administration of these tests were the

same as mentioned by Fleishman and were as follows:

Pull-ups to exhaustion: This was the familiar pull-ups test with some modification. At the start, the subject hung from the bar with the palms facing the body. At the start signal, he pulled himself straight up until his chin was just over the bar, and then he let himself down until his arms were fully extended to complete the cycle. The subject was told to continue until unable to do any more. He was cautioned against kicking and twisting, or stopping in any one position for more than two seconds. Observers stopped any excessive swaying. The examiner counted aloud and if the subject's arms were not fully extended, or if the chin did not reach the bar, he counted "one-half" instead of "one." The examiner demonstrated one chin. The bar used was a Gym Master portable horizontal bar one and one-eighth inches in diameter and eight feet off the ground. The score was the number of chins completed. (15:47)

Parallel bar dips to exhaustion: The subject supported himself between parallel bars (Nissen Corporation, 5'5" high, and shoulder width separation at the center) with his elbows extended. At the signal "start," he lowered himself until there was a ninety degree angle between his forearm and his upper arm, with his upper arm parallel to the floor. He was cautioned that lowering past this position would make it much harder for him to raise himself again, and he was required to raise himself all the way up to the start position to complete one cycle. After a demonstration

the subject was instructed to do as many dips as he could. He was not to stop in the up or down position for more than three seconds. If he started to sway excessively, the observer placed his hand against the subject's legs to stop the swaying. The score was the number of times the subject returned to the starting position without stopping for three seconds at any point. (15:48)

Static strength. This factor was measured by using a grip dynamometer manufactured by the C. H. Stoelting company of Chicago, Illinois. The hand grip test received the highest factor loading (.72) on the static strength factor reported by Fleishman (15:65) This factor emphasized that a maximum force must be exerted for a brief period of time. Reliability estimates as high as .95 have been reported for this test (27: 266) The grip dynamometer used in this study had an adjustable handle to fit the size of the hand and a needle indicator to mark the score in kilograms. Measurements were recorded on each of four trials per hand.

Grip strength test: The subject placed the dynamometer in his palm, dial up, fingers curled over so that the part of the fingers between the second and third knuckles were touching the grip. The subject bent his arm at ninety degrees, away from his side. At the command "squeeze," he was instructed to squeeze the dynamometer once, sharply, as hard as possible. Scores were recorded on each of four trials on each hand.

Extent flexibility. Extent flexibility was the factor which allowed the individual to flex or stretch the trunk, back, and hamstring muscles as far as possible in either a forward or backward direction. The tests used to measure this factor were: (1) the Wells and Dillon modified sit and reach test (51:115), and (2) the simple bridge-up. (27: 201) The modified sit and reach test was used to determine the amount of flexion of the hip and back as well as the elasticity of the hamstring muscles. The simple bridge-up was designed to measure the extension of the spine. The test-retest reliability as high as .92 has been reported for the modified sit and reach test, while the test-retest reliability as high as .96 has been reported for the simple bridge-up test.(27) The tests used were variations of those administered by Fleishman in determining the extent flexibility factor. The equipment used in the modified sit and reach test was a jump and reach board. The board was slotted to allow for a second board to be placed so as to be adjustable to compensate for the differences in reach. The second board had spring door stops placed one inch apart from four to forty inches from the base, but only the first twenty inches were used in this adaptation. (56:21) The only equipment used in the bridge-up test was a tape measure and a 5' by 10' American Panelite mat.

The modified sit and reach test: The subject assumed a sitting position on the floor with the legs at right angles to the edge of the mat.

The heels were in contact with the edge of the jump and reach board and the feet were spaced enough to allow the board to pass ten inches up the leg. A partner's feet were used to brace the board and to keep it from slipping as the subject leaned forward. The subject was instructed to keep his legs straight at all times and lean as far as possible over the board. With his arms extended, he was told to touch the farthest marker on the board after he was as far forward as he could go. The score was recorded to the nearest inch on each of four trials after a demonstration was shown to the subjects. (57:115)

The bridge-up test: From a supine position on the mat, the subject was instructed to extend the hips upward by arching the back and walking the hands and feet as close together as possible. The arms were kept as straight as possible and alongside the head. The score on the test was the measurement of the distance between the finger tips and the heels of the feet. A low score reflected the degree of the flexibility present in the spine. Scores were recorded on each of four attempts after a demonstration was given to the subjects. (27:201)

Dynamic Flexibility. The dynamic flexibility factor was measured by using the bend, twist, and touch test cited by Fleishman, and a test for shoulder girdle flexibility developed by the author. The bend, twist, and touch test measured the speed with which the subject could flex, extend, and rotate his spine, while the shoulder dislocate test measured the

ability of the subject to dislocate the shoulders as required in gymnastics and tumbling. The dynamic flexibility factor involved the ability to make repeated, rapid, flexing movements where the extent of the movements was either short or long. (15:78) The factor loading for the bend, twist, and touch test was noted by Fleishman as .50. (15:76) The test for shoulder girdle flexibility was developed by the author to measure the dynamic flexibility in the shoulders needed in gymnastics and tumbling. Direction for the administration of the tests were as follows:

The bend, twist, and touch test: The subject stood with his back to the wall and far enough from the wall so that he could bend over without hitting the wall with his buttocks. His feet were shoulder width apart. An "X" was placed on the wall in chalk or tape, directly behind the middle of the subject's back and at shoulder height. Another "X" was made on the floor between the subject's feet. On the signal "Go" the subject bent forward and touched the "X" between his feet with both hands and then straightened up and touched the "X" on the wall with both hands. This represented one cycle. The next cycle was the same except that the subject twisted to the opposite side and continued to alternate the side to which he twisted in each successive cycle. The subject's score was the number of cycles completed in twenty seconds as measured by a stop watch. Three trials of this test were administered after the subjects were familiar with the testing procedures. (15:79)

The shoulder dislocate test: The subject grasped a wooden rod four feet in length behind his back with his palms facing forward. He was then instructed to bring the wooden rod over his head with straight arms, and at the same time, to a position in front of his body with the arms ending in a dislocated position. The distance was measured from little finger to little finger, and the scores on each of two attempts were recorded to the nearest inch. The closer the subject was able to bring his hands together while keeping them straight, the greater the amount of flexibility in the shoulder girdle area.

Dependent Variable

There were fifty-two tumbling stunts and two tumbling routines which served as the dependent variable in this study. The stunts were composed of beginning and low intermediate level of difficulty as recognized by the International Gymnastics Federation. (41) A list of the fifty-two stunts is furnished in Appendix A. A scoring scale was determined after a pilot study was conducted and it was determined that an increase in the variability in scoring was needed. The scoring scale increased this scoring variability as well as informed the student of how well he was doing. Scoring for the selected stunts was as follows:

0 = stunt not executed

1 = poor execution

2 = fair execution

3 = good execution

4 = very good execution

There were also two tumbling routines presented which were composed of basic tumbling stunts. The routines were scored on a 5.0 point basis for each routine. The routines presented were as follows:

Routine 1 -

1. Dive forward roll
2. Jump 1/1 turn
3. Forward roll
4. Jump 1/2 turn in the opposite direction of the 1/1 turn
5. Straight leg backward roll to a stand.

The first routine was composed of those elements selected by Metheny (42) as good indicators of motor educability. The only difference was that the stunts were done in sequence rather than separately.

Routine 2 -

1. Cartwheel with 1/4 turn
2. Round-off
3. Jump 1/2 turn
4. Forward roll
5. Dive forward roll

The routines were to be presented in as smooth a manner as possible. Scoring of the routines was done after the subjects had time to

practice and familiarize themselves with what was required for successful completion of the routines. Students were allowed two attempts per stunts and one attempt per routine. The scores for the fifty-two stunts and the two routines were summed and this score served as the dependent variable of tumbling achievement. Separate scores were computed for the Monday-Wednesday-Friday sample and the Tuesday-Thursday sample. The stunts were evaluated daily during the class meetings and the routines were evaluated during the fifth and sixth week of the semester. The same procedures were followed in both the Monday-Wednesday-Friday sample and the Tuesday-Thursday sample.

The author served as the sole judge. The author was qualified to serve in this capacity as he had judged gymnastics competition at all levels of difficulty as well as having been a competitor and assistant gymnastics coach during his thirteen years of experience.

General Procedures

Instruction during the six weeks of testing consisted of demonstrations of the fifty-two selected tumbling stunts used to measure tumbling achievement and skill instruction and practice of the selected tumbling stunts and routines. The independent variables consisted of factor scores obtained through factor analysis of two tests of dynamic strength, two tests of static strength, two tests of extent flexibility, and two tests

dynamic flexibility. The dependent variable consisted of the summation of scores obtained on the fifty-two selected tumbling stunts and scores obtained on the two selected tumbling routines. The dependent and independent variables were obtained according to the following schedule:

Week 1	-	Dynamic strength tests and tumbling stunts
Week 2	-	Static strength tests and tumbling stunts
Week 3	-	Extent flexibility tests and tumbling stunts
Week 4	-	Dynamic flexibility tests and tumbling stunts
Week 5	-	Routine 1 and tumbling stunts
Week 6	-	Routine 2 and tumbling stunts

The selected tests to measure the independent variables were administered at the beginning of each class. Students were tested on any of the fifty-two tumbling stunts after they felt that they had achieved an acceptable level of performance, while the routines were evaluated only during the fifth and sixth weeks of class after sufficient time was allowed for the students to familiarize themselves with the routines.

Limitations of the Testing Procedures. An attempt was made to maintain consistent testing conditions for both groups. It was noted that some individuals did accomplish quite a few more tumbling stunts than others. This was due, perhaps, to the lack of fear demonstrated by these individuals, increased motivation, as well as their possessing a greater ability in the factors of strength and flexibility.

Statistical Procedures

In order to test the research hypothesis that the basic abilities of strength and flexibility were related to tumbling skill achievement, two different samples were used. Sample one consisted of forty-two subjects which met class three times per week for one hour. The second sample was composed of twenty-eight subjects which met class two times per week for one and one-half hours. A separate analysis for each group was used to test the research hypothesis.

Reliability estimates for the tests of the independent variables were estimated with the intraclass reliability model cited by Baumgartner. (5) The dependent variables of tumbling stunts and routines used a scoring scale of 0-4 for the tumbling stunts and 0-5 for the two selected routines. A t-ratio was used to determine if the independent and dependent variables could be considered random samples from the same population. (47) The Shapiro-Wilk test (52) was used to test the normality of distribution for the dependent variables. The eight tests of the independent variables of dynamic strength, static strength, extent flexibility, and dynamic flexibility were factor analyzed (9) with an incomplete principle components analysis with a varimax rotation. (29) Factor scores were computed for each factor and served as the independent variables for the study. A multiple regression model was used to determine the

extent of the relationship and the significance of each factor to tumbling skill achievement.

All scores were punched onto IBM cards and the data were computed at the University of Houston computing facilities.

Chapter 4

REPORT AND ANALYSIS OF DATA

The problem of this study was to test the research hypothesis that the basic abilities of strength and flexibility are related to achievement of basic tumbling skills. Two different samples were used to test the hypothesis. The first sample consisted of forty-two male college subjects enrolled in a basic instruction class which met for one hour on Monday-Wednesday-Friday. A second sample consisted of twenty-eight male college students enrolled in a basic instruction class which met on Tuesday and Thursday for one and one-half hours per class. The basic instruction classes were tumbling classes which were twelve weeks in length. Separate analyses were conducted for each group to test the research hypothesis. The two samples of subjects were tested on two dynamic strength tests, two static strength tests, two extent flexibility tests, and two dynamic flexibility tests. The subjects' tumbling achievement was measured by the sum of fifty-two selected tumbling stunts and two tumbling routines composed of basic tumbling stunts. The data were analyzed to determine the relationship of these basic abilities to skill achievement.

Descriptive Statistics

Presented in Table 1 and Table 2 are the units of measurements, means, standard deviations, and the reliability estimates for the independent variables of the two samples used in the study. Intraclass reliability estimates were computed for the selected tests with the method outlined by Baumgartner. (5)

The tests for the independent variables all had reliability estimates greater than .90, with the exception of the bend, twist, and touch test. The reliability estimates for the pull-ups test and the dip test were not estimated as these two tests have been shown to be highly reliable with samples of college men. (27:243) These findings were consistent between the two samples.

Table 3 contains the t-ratio used to determine if the independent and dependent variables could be considered random samples from the same population. (47) The results of the t-test confirmed the fact that all variables could be considered random samples from the same population as all t-ratios were non-significant.

The dependent variable for both samples was tested for normality of distribution by using the method reported by Shapiro and Wilk. (52) The computed "W" statistic for the Monday-Wednesday-Friday sample ($N = 42$) was .919 which was non-significant. This indicated that the data were normally distributed for this sample. The computed "W" statistic

Table 1

The Unit of Measurement, Mean, Standard Deviation, and Reliability for the Raw Data of the Monday-Wednesday-Friday Sample (N = 42)

Variable	Unit of Measurement	Mean	Standard Deviation	R_{jj}
1. Pull-ups	Total repetitions	10.524	3.373	*
2. Dips	Total repetitions	12.405	5.432	*
3. Right Grip	Kilograms	51.381	7.765	.96
4. Left Grip	Kilograms	48.952	7.499	.95
5. Sit and Reach	Inches	14.048	3.907	.99
6. Bridge-up	Inches	28.190	6.722	.95
7. Shoulder Dislocate	Inches	35.024	6.119	.93
8. Bend, Twist, and Touch	Cycles in 20 seconds	22.357	2.428	.74
9. Tumbling Skill Achievement	Total Points	44.024	26.189	*

*Reliability estimate not computed.

Table 2

The Unit of Measurement, Mean, Standard Deviation, and Reliability Estimate for the Raw Data Tuesday-Thursday Sample (N = 28)

Test	Unit of Measurement	Mean	Standard Deviation	R_{jj}
1. Pull-ups	Total repetition	11.321	5.048	*
2. Dips	Total repetition	12.178	5.221	*
3. Right Grip	Kilograms	52.000	7.257	.95
4. Left Grip	Kilograms	48.214	7.345	.94
5. Sit and Reach	Inches	14.000	3.209	.98
6. Bridge-up	Inches	28.071	8.009	.97
7. Shoulder Dislocate	Inches	32.250	6.676	.97
8. Bend , Twist, and Touch	Cycles in 20 seconds	22.786	2.872	.66
9. Tumbling Skill Achievement	Total Points	44.4286	28.5052	*

*Reliability estimate not computed.

Table 3

t-test for Differences Between the Selected Samples

Test	Mean Difference	Standard Error	t-Ratio
1. Pull-ups	- .797	1.022	- .780
2. Dips	.227	1.324	.171
3. Right Grip	- .619	1.873	- .330
4. Left Grip	.738	1.841	.401
5. Sit and Reach	.048	.902	.052
6. Bridge-up	.119	1.798	.066
7. Shoulder Dislocate	2.774	1.571	1.765
8. Bend, Twist, and Touch	- .429	.647	.081
9. Tumbling Skill Achievement	- .405	6.718	- .060

for the Tuesday-Thursday sample (N = 28) was .921 which was significant at the .01 level. This value indicated that the Tuesday-Thursday sample deviated from a normal distribution. The scores for the dependent variable were therefore converted to T-scores using the percentile rank transformation method reported by Roscoe. (47)

Factor Analysis of the Independent Variables

The product-moment intercorrelations among the eight selected tests are presented in Table 4 for the Monday-Wednesday-Friday sample and in Table 5 for the Tuesday-Thursday sample. The Monday-Wednesday-Friday sample was composed of forty-two subjects and a correlation of .393 or higher was necessary for a correlation to significantly differ from zero at the .01 level of confidence, and a correlation of .304 or higher was needed for it to be significant at the .05 level of confidence. The Tuesday-Thursday sample was composed of twenty-eight subjects and a correlation of .437 or higher was needed to be significantly different from zero at the .01 level of confidence, and .317 or higher for significance at the .05 level of confidence. Negative correlations obtained on the bridge-up test and the shoulder dislocate test are due to the method the test was scored. The low score on these tests indicated that the individual possessed a greater degree of flexibility.

The correlation matrices were factor analyzed by the incomplete principle components models with an orthogonal varimax rotation. (9, 29)

Table 4

Table of Intercorrelations: Monday-Wednesday-Friday Sample

Test	1	2	3	4	5	6	7	8
1. Pull-ups	1.000							
2. Dips	.668[b]	1.000						
3. Right Grip	.323[a]	.169	1.000					
4. Left Grip	.197	.034	.864[b]	1.000				
5. Sit and Reach	.148	.008	.189	.288	1.000			
6. Bridge-up	- .218	.015	- .058	- .026	- .541[b]	1.000		
7. Shoulder Dislocate	.002	- .060	- .236	- .238	- .369[a]	.290	1.000	
8. Bend, Twist, and Touch	.340[a]	.139	.191	.128	.494[b]	- .424[b]	- .242	1.000

[a]Significant at the .05 level of confidence.

[b]Significant at the .01 level of confidence.

Table 5

Table of Intercorrelations: Tuesday-Thursday Sample

Test	1	2	3	4	5	6	7	8
1. Pull-ups	1.000							
2. Dips	.751[b]	1.000						
3. Right Grip	.160	.030	1.000					
4. Left Grip	.130	.068	.753[b]	1.000				
5. Sit and Reach	.169	.027	.428[a]	.407[a]	1.000			
6. Bridge-up	- .188	.009	- .047	- .178	- .527[b]	1.000		
7. Shoulder Dislocate	.069	- .051	.193	.001	.061	.085	1.000	
8. Bend, Twist, and Touch	.214	.218	.231	.150	- .068	.276	- .204	1.000

[a]Significant at the .05 level of confidence.

[b]Significant at the .01 level of confidence.

The analyses yielded three basic factors for the Monday-Wednesday-Friday sample and four basic factors for the Tuesday-Thursday sample. The rotated factor matrices are presented in Tables 6 and 7. Factor scores which provide the most internally consistent score to represent each factor were used for the independent variables. The intercorrelations among factor scores are uncorrelated.

The factor analyses produced similar results with the exception of the flexibility factors. The three factors for the Monday-Wednesday-Friday sample were identified as: Flexibility (F_1), Static Strength (F_2), and Dynamic Strength (F_3). For this sample the flexibility factor consisted of both extent and dynamic type flexibility actions. The four factors identified for the Tuesday-Thursday sample were: Static Strength (F_1), Dynamic Strength (F_2), Extent Flexibility (F_3), and Dynamic Flexibility (F_4). The communality estimates (h^2) for both samples revealed that the fourth factor (Dynamic Flexibility) of the Tuesday-Thursday sample increased the common variance of the dynamic flexibility tests: shoulder dislocate and bend, twist, and touch. This was probably due to the fact that extent flexibility tests required the individual to stretch or extend the body as far as possible in some direction, while the dynamic flexibility tests only required the ability to make repeated rapid movements which involved muscle flexibility. Inasmuch as the tumbling stunts that were presented were primarily of a dynamic type, the dynamic

Table 6

Rotated Factor Matrix for Eight Variables
Monday-Wednesday-Friday Sample

Test	F_1	F_2	F_3	h^2
1. Pull-ups	.171	.153	.897	.858
2. Dips	- .038	.034	.894	.801
3. Right Grip	.091	.933	.194	.916
4. Left Grip	.110	.957	.026	.928
5. Sit and Reach	.824	.178	- .012	.710
6. Bridge-up	- .815	.100	- .063	.678
7. Shoulder Dislocate	- .547	- .297	.120	.402
8. Bend, Twist and Touch	.713	.042	.291	.594

Table 7

Rotated Factor Matrix for Eight Variables
Tuesday-Thursday Sample

Tests	F_1	F_2	F_3	F_4	h^2
1. Pull-ups	.103	.931	-.121	.048	.895
2. Dips	-.013	.927	.047	-.055	.864
3. Right Grip	.931	.046	-.005	.140	.888
4. Left Grip	.877	.031	-.148	-.054	.796
5. Sit and Reach	.504	.074	-.683	.022	.726
6. Bridge-up	-.051	-.083	.903	.104	.836
7. Shoulder Dislocate	.116	.038	.077	.948	.920
8. Bend, Twist, and Touch	.374	.289	.537	-.464	.727

flexibility factor reflected the emphasis in terms of factor scores. These findings were in agreement with the findings of Fleishman, (15) Harris, (20) and Liba (35); namely that certain basic abilities can explain performance in certain skills.

The Relationship Between Basic Abilities and Tumbling Achievement

Multiple regression was used to test the hypothesis to determine if the basic abilities of strength and flexibility are related to tumbling skill achievement. Restricted models contrasting less than all of the independent variables were compared to the full model consisting of all the independent variables. This procedure was used to identify the factors that were significantly related to tumbling skill achievement. The BMD02R stepwise regression analysis program was used for the regression analysis. (13) This program computed a sequence of multiple linear regression equations in a stepwise manner. At each step the variable which made the greatest reduction in the error sum of squares was added to the regression equation. Additionally, it was the variable which had the highest partial correlation with the dependent variable partialed on the variables which have been added; also it was the variable which, if added, would have the highest F-ratio value. (13)

Reported in Tables 8 and 9 are the multiple regression analyses

of the full model samples. Included is the step each variable was added to the regression equation, the multiple correlation (R) for that step, the coefficient of determination (R^2), and the additional variance added at each step. For the Monday-Wednesday-Friday sample, the data suggested that after the second step there was little increase in the coefficient of determination. These findings were consistent with the Tuesday-Thursday sample analysis. These analyses indicated that for the Monday-Wednesday-Friday sample, the factors of dynamic strength and general flexibility accounted for the largest amount of shared variance between the independent variables and the dependent variable. For the Tuesday-Thursday sample, the factors of dynamic strength and dynamic flexibility were the most important variables contributing to the shared variance.

Table 8

Stepwise Regression Analysis for the Monday-Wednesday-Friday Sample

Step	Independent Variable	R	R^2	Increase R^2
1	Dynamic Strength	.357	.127	.127
2	Flexibility	.483	.233	.106
3	Static Strength	.517	.261	.028

The F-ratios were computed for the full and restricted models for both samples. This procedure allowed the investigator to determine if the

Table 9
Stepwise Regression Analysis for the
Tuesday-Thursday Sample

Step	Independent Variable	R	R^2	Increase R^2
1	Dynamic Strength	.663	.440	.440
2	Dynamic Flexibility	.747	.558	.118
3	Extent Flexibility	.761	.580	.025
4	Static Strength	.765	.586	.006

factors identified through factor analysis were significantly related to tumbling skill achievement. Presented in Tables 10 and 11 are the F-ratios for the full models for each sample. The calculated F-ratios indicate that the multiple correlation for the full models were significantly different than zero.

Table 10

Derived F-Ratio for the Full Model
Monday-Wednesday-Friday Sample

Source of Variance	df	SS	MS	F
Regression	3	1056.775	325.258	4.470[a]
$Residual_{(Full)}$	38	2996.675	78.807	

[a]Significant at the .05 level of confidence.

Table 11

Derived F-Ratio for the Full Model
Tuesday-Thursday Sample

Source of Variance	df	SS	MS	F
Regression	4	1622.613	405.653	8.132[a]
$Residual_{(Full)}$	23	1147.334	49.884	

[a]Significant at the .01 level of confidence.

Presented in Tables 12 and 13 are the full versus the restricted models for the two samples. The results indicated that for the Monday-Wednesday-Friday sample, static strength did not contribute significantly to tumbling skill achievement, while dynamic strength and general flexibility did contribute to tumbling skill achievement. This was probably due to the nature of the selected tumbling stunts which were primarily dynamic type stunts which required dynamic strength and flexibility in order to accomplish them. For the Tuesday-Thursday sample, the results indicated that after the first two factors (dynamic strength and dynamic flexibility) were considered, the remaining factors (extent flexibility and static strength) were relatively unimportant to tumbling skill achievement. This was also due to the dynamic type action required to accomplish the majority of the stunts. For each group, the most important factor was dynamic strength. Dynamic flexibility was specified in the Tuesday-Thursday

Table 12

F-Ratio Between Full and Restricted Models
Monday-Wednesday-Friday Sample

Source of Variance	df	SS	MS	F
Full vs. Flexibility and Dynamic Strength				
$Regression_{(Diff)}$	1	111.78	111.78	1.42
$Residual_{(Full)}$	38	2996.675	78.807	
Full vs. Dynamic Strength				
$Regression_{(Diff)}$	2	540.964	270.482	3.43[a]
$Residual_{(Full)}$	38	2996.675	78.807	

[a]Significant at the .05 level of confidence.

Table 13

F-Ratio Between Full and Restricted Models
Tuesday-Thursday Sample

Source of Variance	df	SS	MS	F
Full vs. Dynamic Strength, Extent Flexibility, and Dynamic Flexibility				
$Regression_{(Diff)}$	1	16.832	16.832	.337
$Residual_{(Full)}$	23	1147.334	49.884	
Full vs. Dynamic Strength and Dynamic Flexibility				
$Regression_{(Diff)}$	2	76.274	38.137	.764
$Residual_{(Full)}$	23	1147.334	49.884	
Full vs. Dynamic Strength				
$Regression_{(Diff)}$	3	403.510	134.503	2.696[a]
$Residual_{(Full)}$	23	1147.334	49.884	

[a]Significant at the .10 level of confidence.

sample, while only general flexibility, composing dynamic and extent types of flexibility, was an important factor in the Monday-Wednesday-Friday sample. The nonsignificant F-ratio for the static strength factor indicated that by dropping the static strength variable, the multiple correlations were not affected in either sample.

Summary

The data obtained from the selected tests and tumbling stunts and routines were analyzed. The intraclass reliability estimates for the selected tests were computed and all coefficients were above .90 with the exception of the bend, twist, and touch test. The data were tested for random selection from the observed population by means of the t-test and all t-ratios were nonsignificant. The data for the dependent variable were not found to be normally distributed and were converted to T-scores using the percentile rank transformation method.

Factor analysis was used to isolate the independent variables used in the analyses. Three factors were identified for the Monday-Wednesday-Friday sample and were: Flexibility (F_1), Static Strength (F_2), and Dynamic Strength (F_3). Analyses for the Tuesday-Thursday sample identified four factors and were: Static Strength (F_1), Dynamic Strength (F_2), Extent Flexibility (F_3), and Dynamic Flexibility (F_4).

Multiple regression analysis was used to determine the relationship between the independent variables and the dependent variable. These

findings revealed that dynamic strength and flexibility were significantly related to tumbling skill achievement. A general flexibility factor was identified for the Monday-Wednesday-Friday sample composed of extent and dynamic type flexibility actions, while for the Tuesday-Thursday sample the flexibility factor was specified as being of the dynamic type. This was due to the dynamic type actions required to successfully accomplish the majority of the selected tumbling stunts.

Chapter 5

SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

The problem of this study was to determine the relationship of strength and flexibility to basic tumbling skill achievement. Since research relative to this problem was not found, a review of literature was conducted to determine the tests which would best measure the factors of strength and flexibility. Two tests were administered for each of the factors of dynamic strength, static strength, extent flexibility, and dynamic flexibility. The dependent variable was composed of the summation of scores achieved on each of the fifty-two selected tumbling stunts and two tumbling routines composed of basic tumbling stunts.

There were two samples used to replicate the findings of this study. Sample one was composed of forty-two subjects which met class three times per week, while the second sample was composed of twenty-eight subjects which met class two times per week.

The data were factor analyzed and multiple regression analysis was used to test the research hypothesis that the basic abilities of strength and flexibility are related to tumbling skill achievement.

Findings

1. The basic abilities of strength and flexibility were related to tumbling skill achievement.

2. Dynamic strength and dynamic flexibility were the important factors in determining tumbling skill achievement.

3. Static strength and extent flexibility were relatively unimportant in determining tumbling skill achievement.

Discussion of Findings

The findings of this study indicate that dynamic strength and flexibility, particularly of the dynamic type, were significantly related to tumbling skill achievement. Also, individual differences in basic abilities possessed by a student prior to instruction is related to skill achievement. The findings of this study will also be useful in diagnosing and predicting student performance. By holding skill achievement constant, those that possess these basic abilities may achieve at a higher level since there are general components that account for individual differences in skill achievement. Tumbling is a dynamic type activity, hence the basic abilities most related to its achievement are those of the dynamic type such as dynamic strength and dynamic flexibility.

Conclusions

1. The research hypothesis that basic abilities are related to skill achievement was confirmed.

2. The basic abilities of strength and flexibility are related to tumbling skill achievement.

Recommendations

On the basis of the findings of this study, the investigator offers the following recommendations for further study:

1. The basic abilities which compose basic tumbling skills should be expanded in order to explain the successful acquisition of tumbling skill.

2. The investigation should be conducted using samples of different levels of achievement.

3. The principles used in the conduct of this study should be applied to other activities in physical education in order to provide data needed to develop instructional programs of physical education.

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APPENDIX A

TABLE OF TUMBLING STUNTS PRESENTED

1. Forward roll
2. Dive roll
3. Forward roll to straddle
4. Forward roll walk out
5. Piked forward roll
6. Back dive 1/2 twist forward roll
7. Dive to handstand forward roll out
8. Back roll tucked
9. Back roll piked
10. Back roll extension walk out
11. Back roll extension snap down
12. Back roll extension to straddle
13. Back roll to head balance
14. Back roll to hand stand
15. Forward roll cross leg transition back roll
16. Forward roll jump 1/2 turn back roll
17. Forward roll jump full turn forward roll
18. Back roll jump 1/2 turn forward roll
19. Back roll jump full turn back roll
20. Floor kip
21. Floor kip with 1/2 twist
22. Headspring
23. Reverse kip to front rest position
24. Reverse kip to hand stand
25. Cartwheel
26. Near arm one arm cartwheel
27. Forward handspring
28. Backward Handspring
29. Roundoff
30. Flank around
31. Squat through
32. Straddle through
33. Dead man fall
34. Swedish fall
35. Front rest leg swing 1/4 turn to straddle stand
36. Single leg circles
37. Straddle stand
38. V-sit
39. L-support
40. V-support
41. Straddle L-support
42. Front scale
43. Side Scale

44. Squat hand balance
45. Two arm elbow lever
46. Head balance
47. Head elbow balance
48. Forearm balance
49. Head elbow balance press to forearm balance
50. Press to head balance from straddle stand
51. Kick hand stand
52. Press to hand stand

APPENDIX B

LIST OF MEAN SCORES FOR THE SELECTED TESTS AND TOTAL POINTS FOR TUMBLING SKILL ACHIEVEMENT FOR THE MONDAY-WEDNESDAY-FRIDAY CLASSES (N = 42)

Subject's Number	Pull-ups	Dips	Right Grip	Left Grip	Sit and Reach	Bridge-up	Shoulder Dislocate	Bend, Twist, and Touch	Total Points
01	07	10	59	57	15	36	40	20	34
02	10	10	58	53	10	36	38	19	44
03	12	20	58	49	10	38	42	24	16
04	09	10	70	63	15	26	23	23	70
05	12	20	46	44	06	32	42	22	42
06	12	13	46	47	15	25	31	19	50
07	13	17	58	55	10	34	37	22	51
08	08	10	40	34	12	22	37	25	21
09	04	10	46	40	15	38	31	20	11
10	10	09	45	53	13	38	39	20	20
11	10	13	53	48	12	31	37	22	35
12	10	13	44	45	12	24	35	21	49
13	05	13	41	40	10	34	34	16	44
14	07	06	53	44	05	36	33	21	18
15	11	15	51	50	16	22	30	20	32
16	12	10	47	44	05	35	43	20	25
17	07	02	44	45	08	35	44	17	13
18	13	12	63	60	14	24	26	23	54
19	12	13	52	53	17	23	35	24	72
20	19	30	61	55	11	30	33	23	51
21	11	10	45	46	17	26	37	23	86
22	06	10	36	34	10	35	44	24	19
23	15	25	55	48	18	25	39	22	83
24	08	15	54	62	15	32	30	23	19
25	10	11	50	48	19	18	32	22	30
26	10	15	53	53	14	38	39	21	37
27	10	10	61	58	19	22	19	24	24
28	07	07	50	44	10	30	37	19	06
29	10	05	57	61	19	33	33	26	49
30	11	06	48	46	14	15	42	23	12

APPENDIX B (Cont'd)

Subject's Number	Pull-ups	Dips	Right Grip	Left Grip	Sit and Reach	Bridge-up	Shoulder Dislocate	Bend, Twist, and Touch	Total Points
31	16	15	44	41	14	25	23	25	22
32	10	11	43	41	17	19	40	24	64
33	20	21	56	47	17	26	35	27	89
34	13	17	50	47	17	17	38	23	87
35	08	08	49	53	16	30	35	25	95
36	10	05	71	66	17	14	40	25	82
37	15	17	61	56	16	31	37	21	71
38	11	10	55	50	19	31	38	25	11
39	10	10	44	45	19	27	40	22	91
40	05	10	45	43	17	21	22	25	14
41	10	17	50	48	18	23	27	25	57
42	13	10	46	40	17	27	34	24	39

APPENDIX C

LIST OF MEAN SCORES FOR THE SELECTED TESTS AND TOTAL POINTS FOR TUMBLING SKILL ACHIEVEMENT FOR THE TUESDAY-THURSDAY CLASSES (N = 28)

Subject's Number	Pull-ups	Dips	Right Grip	Left Grip	Sit and Reach	Bridge-up	Shoulder Dislocate	Bend, Twist, and Touch	Total Points for Tumbling
01	11	16	58	45	17	38	33	27	43
02	09	18	49	28	13	27	29	16	71
03	09	11	46	38	14	31	29	21	31
04	17	16	49	44	10	27	37	23	72
05	15	13	57	48	19	18	33	20	34
06	04	06	47	48	15	27	30	17	17
07	24	23	42	38	14	20	36	23	99
08	22	20	51	51	16	26	25	24	39
09	11	10	64	56	19	25	42	20	15
10	07	13	43	37	07	31	26	27	29
11	07	05	57	56	15	09	20	23	24
12	13	11	49	45	17	18	41	18	11
13	17	17	53	58	12	35	21	24	72
14	15	17	49	46	15	13	25	23	89
15	17	18	67	69	18	19	41	25	49
16	06	05	37	34	10	32	33	19	19
17	03	02	47	46	12	25	41	21	17
18	08	11	55	47	09	41	32	23	27
19	15	10	67	51	10	37	43	23	20
20	12	15	42	46	10	39	42	24	72
21	05	08	53	54	16	26	36	22	19
22	10	20	56	49	14	35	35	25	63
23	11	08	52	41	13	36	32	24	19
24	09	12	52	56	11	38	23	24	46
25	10	11	50	46	17	27	24	26	54
26	10	07	49	48	17	28	33	25	61
27	12	08	60	55	16	28	31	26	63
28	08	10	55	50	16	30	30	25	69