Summer 6-1-1960

A Comparison of Performance Tests of Balance of Children With and Without Auditory Handicaps

Joanne Baker Overman

A COMPARISON OF PERFORMANCE TESTS - OVERMAN

NAME AND ADDRESS	DATE

A COMPARISON OF PERFORMANCE TESTS OF BALANCE OF CHILDREN WITH AND WITHOUT AUDITORY HANDICAPS

A Thesis
Presented to
the Faculty of the Department
of Physical Education
University of New Mexico

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by
Joanne Baker Overman
June 1960

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[illegible]

June [illegible]

This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of the University of New Mexico in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

E H Castetter
DEAN

June 1, 1960
DATE

Thesis committee

Lloyd R. Burley
CHAIRMAN

Wm B Runge

Armand H. Seidler

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CHAPTER I

INTRODUCTION

Sports and other active leisure-time pursuits are enjoyed by many people but usually to a greater degree if they are done well. Many skills are fundamental to daily existence and are learned through repeated use. These, too, are more satisfying if done well.

Physical educators have generally agreed that good body control and maintenance of equilibrium, or balance, are important factors in all such activities.

Persons suffering from deafness or loss of hearing may have an impaired sense of balance because some of the same mechanisms are involved in the functions of hearing and balance.

I. DEFINITION AND DISCUSSION OF TERMS

Balance or Equilibrium. A body is most stable when the center of gravity is directly over the center of the base of support, and becomes unstable as the center of gravity moves outside the base of support. The ability to maintain this equilibrium has been dis-

cussed by many writers. Bass[1] considers balance as an element of motor skill and also as a fundamental skill. Larson and Yocom state that:

> Balance is the ability of the individual to control organic equipment neuromuscularly. Balance is also related to the components of coordination, and in some skills, to agility.[2]

Wells states that, "One of the basic skills in physical activities is the ability to maintain one's balance under unfavorable circumstances."[3] Proficiency in physical activities will be difficult if loss of balance occurs before or during execution of the skill. Morehouse and Cooper firmly believe that:

> If balance is not maintained during a skillful, rapid, or forceful movement, neuromuscular coordination will be obstructed, speed and agility will be reduced, and the application of force will be ineffectual.[4]

Static and Dynamic Balance. There is a general agreement on the definitions given the two terms, 'static'

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[1]Ruth I. Bass, "An Analysis of the Components of Tests of Semicircular Canal Function and of Static and Dynamic Balance," Research Quarterly, 10:33-52, May, 1939.

[2]Leonard A. Larson and Rachael Dunaven Yocum, Measurement and Evaluation in Physical, Health and Recreation Education (St. Louis: C. V. Mosby Company, 1951), p. 161.

[3]Katharine Wells, Kinesiology (Philadelphia: W. B. Saunders Company, 1950), p. 12.

[4]Laurence E. Morehouse and John Cooper, Kinesiology (St. Louis: C. V. Mosby Company, 1950), p. 168.

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[1] Ruth [illegible] Tests of [illegible] Dynamic Balance," [illegible]

[2] Leonard [illegible] Measurement [illegible] Recreation [illegible] 1951), p. 161.

[3] Katharine Wells, [illegible] W. B. Saunders Company, [illegible]

[4] [illegible] (St. Louis: C. V. Mosby Company, [illegible]

and 'dynamic' balance. McCloy defines static balance as, "The kind of balance in which movement is not great and in which adjustments are relatively small," dynamic balance as, "relative steadiness or stability in leaping from one spot to another and holding balance after the leap".[5] Bass states:

> Static balance is that balance in which equilibrium is maintained for one position of the body. Dynamic is the type of balance that is concerned with one's equilibrium while in motion, or while changing from one balanced position to another, through a series of changing positions taken successively.[6]

Scott states, "Any position in which an attempt is made to hold the body stationary is a static one".[7] Seashore states, "Static balance is the maintenance of a specific motionless posture, that may apply to one segment or to the entire body". He points out that in dynamic balance, ". . . the body's weight is so distributed that the resultant of the forces vary from moment to moment".[8]

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[5]Charles H. McCloy, "A Preliminary Study of Factors in Motor Educability," Research Quarterly, 11:28-40, 1940.

[6]Bass, op. cit. p. 33.

[7]M. Gladys Scott, Analysis of Human Motion (New York: F. S. Crofts and Company, 1945), p. 164.

[8]H. G. Seashore, "The Development of a Beam Walking Test and its use in Measuring Development of Balance in Children," Research Quarterly, 18:246-259, December, 1947.

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"The kind of balance in which movement is [illegible] in which adjustments are [illegible] balance as, [illegible] from one spot to [illegible] leap".[5] Same author:

Static balance is that [illegible] in which equilibrium is maintained [illegible]. Dynamic is the type of balance [illegible] with one's equilibrium while in motion, [illegible] changing from one balanced position to another, through a series of changing positions [illegible] successively.

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[5] [illegible] in Motor Ability," [illegible]

[6] Ibid., p. [illegible]

[7] M. Gladys Scott, [illegible] F. S. Crofts and Company, [illegible]

[8] H. G. Seashore, [illegible] Test and Its Use in [illegible] Children," [illegible]

Kinesthesis. Kinesthesis is the sense which furnishes information about the position and movement of body parts by means of sense organs located in the muscles, tendons, and joints. Weibe states that, "Kinesthesis is the position sense, with which physical education concerns itself."[9] He also ascribes kinesthesis as a component of balance. Scott, in a discussion on "Measurement of Kinesthesis," states:

> Balance ability is a specific function of kinesthesis. It is the sensory property of the human being with implications for motor accuracy and precision, individual differences, empathic appreciation, and even determination for neural normalcy.[10]

According to Lee and Wagner[11], kinesthetic awareness is an accurate and conscious control of the body in movement. Roloff states, "The presence of kinesthetic sense has often been one of the factors contributing to the ability of the individual to learn an activity or skill".[12] Many writers have said the higher the level of

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[9] Vernon R. Weibe, "A Study of Tests of Kinesthesis," Research Quarterly, 25:222-230, May, 1954.

[10] M. Gladys Scott, "Measurement of Kinesthesis," Research Quarterly, 26:324-341, October, 1955, p. 330.

[11] Mabel Lee and Miram M. Wagner, Fundamentals of Body Mechanics and Conditioning (Philadelphia: W. B. Saunders Company, 1949), p. 62.

[12] Louise L. Roloff, "Kinesthesis in Relation to the Learning of Selected Motor Skills," Research Quarterly, 24:211-217, May, 1953.

kinesthetic sense possessed by an individual the greater his ability to learn skills.

Balance Mechanisms. These are the physical functions which aid in the perception of balance. McCloy and Young state:

> . . . there is evidence available that indicates that balance, as it is used in physical activities, is dependent upon at least the following items: (1) kinesthetic responses, both sensory and motor . . . (2) visual responses or aid that is obtained from the eyes, and (3) the semicircular canals system. The part this system plays in the finer forms of balance is still an unanswered question. There is some statistical evidence to indicate that these canals, with the ampullae, function separately as well as together in certain forms of balance.[13]

Williams states:

> The internal ear comprises two parts, one concerned with equilibrium, and the other with hearing. Any movement of the head is recorded by a movement of the endolymph in the semicircular canals. The otolith organ gives information about the position of the head.[14]

Morehouse and Cooper also make mention of the eyes in the role of balance:

> When the function of organs of the internal ear is lost, the afflicted individual cannot maintain balance with his eyes closed. Even with visual and

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[13] Charles H. McCloy, and Norma Dorothy Young, Tests and Measurements in Health and Physical Education (New York: Appleton-Century-Crofts, Inc., 1954), p. 103.

[14] Jesse Feiring Williams, Handbook of Anatomy and Physiology (Philadelphia: W. B. Saunders Company, 1943), p. 244.

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<u>Balance Mechanism</u>. [illegible] functions [illegible] of balance.

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> . . . [illegible] that balance [illegible] is [illegible] kinesthetic [illegible], (2) visual [illegible] the eyes, [illegible] The part [illegible] balance is [illegible] semicircular [illegible] canals, [illegible] well as [illegible].

Williams [illegible]

> The [illegible] equilibrium, [illegible] movements [illegible] organ [illegible] head.[18]

[illegible] in the role of [illegible].

> When [illegible] is lost, [illegible] balance [illegible].

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[18][illegible] *Tests and Measurements [illegible]* (New York: [illegible]).

[19][illegible] *Physiology* [illegible] p. [illegible].

> other sensations intact, he is continually losing his balance and struggling to regain it.[15]

Deafness. Deafness, as used in this study, means a total or nearly total hearing loss. The major causes of deafness are heredity, prenatal conditions, brain diseases, accidents, and the infectious and contageous diseases of childhood - scarlet fever, measles, spinal meningitis, typhoid fever, and whooping cough. Otosclerosis, a progressive condition due to changes in the structure of the ear mechanisms, is a major cause of deafness in the older age group.

II. THE PROBLEM

Statement of the Problem. The purposes of this study were to compare the differences in performances in static and dynamic balance tests between: (1) deaf children and hearing children; (2) deaf girls and hearing girls; (3) deaf boys and hearing boys: (4) deaf girls and hearing boys; (5) deaf boys and hearing girls; (6) deaf and hearing boys by age groups; (7) deaf and hearing girls by age groups; (8) the congenital deaf and the infectious deaf; (9) deaf boys and deaf girls; and (10) hearing boys and hearing girls.

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[15] Morehouse, op. cit., p. 134.

other suggestions [illegible] his balance and [illegible].

Deafness. [illegible] was a total of [illegible]. [illegible] deafness and [illegible], [illegible], [illegible] accidents, and the [illegible] childhood – measles [illegible], typhoid fever, [illegible] whooping cough. [illegible], progressive condition due to [illegible] the ear mechanism, [illegible] older age groups.

[illegible]

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[15] [illegible]

<u>Importance of the Study</u>. The study should be of value to the physical educator of the deaf or hard of hearing as well as to the teacher of normal hearing students because the findings should contribute to the understanding of the capacities of individuals in so far as balance is a factor.

III. PROCEDURE

A search was conducted to determine the most useful tests of dynamic and static balance. Bass's Stepping Stone Test of Dynamic Balance and one phase of her Stick Balance Test were chosen. The available students at the New Mexico School for The Deaf in Santa Fe, New Mexico were tested. A group of junior and senior high school students, matching the deaf students in sex and in age to the nearest year, were then chosen and given the same test. The data were analyzed, results discussed, and conclusions reported.

IV. ORGANIZATION OF REMAINDER OF THE STUDY

The material of this study is arranged into five chapters. Chapter II contains the review of the literature related to this study. Chapter III describes the tests of dynamic and static balance, and how they are given. The statistical analysis and discussion of

Importance of the Study. [illegible]

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IV. ORGANIZATION OF [illegible]

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the results are presented in Chapter IV. Chapter V includes the summary, conclusions and recommendations. The bibliography and appendix complete the report.

CHAPTER II

REVIEW OF THE LITERATURE

Some studies concerning balance tests are available. Four studies involving balance were found which dealt with the deaf in particular. The Stepping Stone Test of Dynamic Balance and the floor phase of The Static Balance Test have not been used for comparing deaf and hearing boys and girls.

I. LITERATURE ON BALANCE TESTS AND DEAF SUBJECTS

Walking the balance beam has been used frequently as a test of dynamic balance ability. Myklebust[16] tested two hundred and three subjects on the Heath rails at the New Jersey School for Deaf, using the four inch, two inch, and one inch rails. He classified the deaf into five etiological groups: endogenous, presumptive endogenous, exogenous, undetermined, and meningitic. He reported balance ability progressed with maturation and males were superior to females. He said:

> On the basis of clinical observation the meningitic deaf differed from children deaf from other causes.

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[16] H. R. Myklebust, "Significance of Etiology in Motor Performance of Deaf Children with Special Reference to Meningitis," American Journal of Psychology, 59:249 1946-1947.

> They not only appeared to have difficulty in maintaining equilibrium but they also seemed to present unusually difficult problems in adjustment. This group is decidedly inferior in motor ability when compared to children deaf from other causes.[17]

Long,[18] in 1930, used a battery of six tests to study certain motor abilities of the deaf. He tested one hundred and seventy-four subjects whose ages ranged from eight years to eighteen years. To test their sense of balance he used the one inch wide balance board. He concluded that in general motor ability the deaf compare favorably to the hearing group with the exception of balance ability where the deaf are inferior. Morsh[19] made a comparative study of deaf and hearing students using the Dunlap Balance Board. This is not to be confused with the long beam type device. "The balance board is a platform eighteen inches square, with its median axis resting on ball bearings and using four electric counters."[20] Morsh concluded there is no difference in balance, except when blindfolded, between

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[17] *Ibid.*

[18] John A. Long, *Motor Abilities of Deaf Children* (New York: Bureau of Publications, Teacher's College, Columbia University Press, 1932).

[19] Joseph Eugene Morsh, "A Comparative Study of Deaf and Hearing Students," *American Annals of the Deaf*, 82:223-233, May, 1937.

[20] *Ibid.*

deaf and hearing subjects; no difference between bright and dull deaf subjects; but bright hearing subjects are superior in balance ability to dull hearing subjects. In these tests boys were superior to girls.

Padden[21] in his research investigation of the ability of the deaf to orient themselves under water, discussed the difficulty the meningitic and poor balance group had in coming to the surface. Tests were given with eyes open and blindfolded, and the reliabilities were .74 and .85 respectively. Meyer[22] reports the greatest problem in teaching swimming to the deaf is that of balance. Students often swim to the bottom instead of the top after a dive.

II. LITERATURE ON MOTOR ABILITY AND BALANCE

In 1947 Seashore[23] devised a beam walking test for balance ability. He used nine, ten foot long oak walking beams placed four and one half inches above the floor and of widths varying from one-fourth inch to four inches. He

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[21] Donald D. Padden, "Ability of Deaf Swimmers to Orient Themselves in Water," Research Quarterly, 30:214-226, May, 1959.

[22] H. C. Meyer, "Swimming for the Deaf," Journal of Health, Physical Education and Recreation, 26:12, May, 1955.

[23] Seashore, loc. cit.

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II. LITERATURE [illegible]

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[21] Donald D. Paddon, "[illegible] Orient Themselves [illegible]," [illegible], May, 1939.

[22] [illegible] Health, Physical [illegible] and [illegible].

[23] Seashore, op. cit.

found reliability coefficients of .85 to .89 for the ages five to nineteen when the second fall off was used as the failure point and the Spearman-Brown Prophecy Formula was used to correct for odd-even reliability coefficients for six trials. This method of scoring the second fall off reduces failure due to factors other than motor ability and also provides a uniform set of scores for all ages studied. One of the reasons given for the great range in scores is the relationship of height and weight to balance. Cron and Pronko[24] measured performance on the balance beam of children between the ages of four and fifteen years. Girls performed better in the age group four to eight years, although boys did better from eight to fifteen years. Ability increased with age from the four to six year group up through the eleven and twelve year group. It leveled off and showed a slight decline in the thirteen to fifteen year age group. Espenschade, Dable, and Schoendube[25] used Seashore's beam walking test on four hundred and seventy-six boys from eleven to sixteen years of age. Reliability was found to be .87 and agreed with figures by Seashore

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[24] G. W. Cron, and W. H. Pronko, "Development of the Sense of Balance in School Children," Journal of Educational Research, 5:33-37, September, 1957.

[25] Anna Espenschade, Robert Dable, and Robert Schoendube, "Dynamic Balance in Adolescent Boys," Research Quarterly, 24:270-275, October, 1953.

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six boys from six to eleven years of age [illegible]
was found to be [illegible]

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26 [illegible] Research, [illegible]

27 [illegible] Quarterly, [illegible]

for adult men. They found a consistant gain with age, but the rate of gain from thirteen to fifteen years was noticeably retarded. A retest was done a year later in the same school and with some of the same boys. A coefficient of correlation of .80 indicated no evidence of learning had taken place in the year's time. There was no significant difference found between scores of the original groups of boys and those of grade groups made up of different boys.

Bass[26] devised a static balance test, consisting first of standing on one foot on the floor, and next on a stick, lengthwise and crosswise, eyes opened and closed, standing erect and bending over. The stick used was twelve inches long, one inch high, and one inch wide. She tested two hundred and seventy university women and found reliability ranged from .72 to .90 for the static test. She also devised the Stepping Stone Test of Dynamic Balance which employs eleven targets. The subject leaps from one to the other maintaining balance up to but no longer than five seconds in each target. Bass used this test with three hundred and fifty university women and obtained a reliability coefficient of .95 for three trials. She found a significant relationship between dynamic balance

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[26]Bass, loc. cit.

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bility coefficient of .76 [illegible]. He

also devised [illegible] balance

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reliability coefficient of .7[illegible] three [illegible]. He

found a significant [illegible]

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[26] [illegible], 112-114.

and general motor ability as well as rhythm. Factor analysis showed the function of the eyes to be one of the nine factors of balance. Garrison[27] taught a series of balance lessons to a group of college women and concluded that ability was improved by teaching the principles of balance and the exercises. Lessons affected improvement of dynamic balance more than static balance. Included in the balance lessons was the Stepping Stone Test of Dynamic Balance. Riley[28] used the balance leap and the stick balance tests on three hundred and eight children in the first through the sixth grades. She concluded that ability increased with grade level; dynamic balance appeared to be more difficult for grades one through three than did static balance; children in the fourth, fifth, and sixth grades were more easily motivated in the sideward leap test. Riley states, "Both tests as used in this study have fairly low reliability when used with elementary school children."[29]

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[27] Levon Garrison, "An Experiment in Improving Balance Ability, Through Teaching Selected Exercises," (unpublished Master's thesis, The State University of Iowa, Iowa City, 1953).

[28] Marie Riley, "The Measurement of Balance in the Elementary Grades," (unpublished Masters thesis, The State University of Iowa, Iowa City, 1953).

[29] Ibid.

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[27] Levon Garrison, "[illegible] Balance Ability, [illegible]," (unpublished Master's thesis, [illegible], Iowa, Iowa City, 1935).

[28] Marie [illegible], "[illegible] Elementary [illegible]," [illegible] State University of Iowa, Iowa City, 19[illegible].

[29] Ibid.

Fisher, Birren, and Leggett[30] used the railwalking and the ataxiagraph to test equilibrium. They tested one hundred and fifty-one subjects walking a beam ten feet long, six inches high, and one inch wide. One-hundred and thirty-two subjects were tested on the ataxiagraph which measured body sway while standing vertically. The ataxiagraph consisted of a helmet worn by the subject with a short rod protruding from the top to which a cord was fastened that ran over a pulley. The subject's movement was translated into equivalent vertical movements by an inkwriter on a kymograph. They found the ataxiagraph scores more reliable; no relation existed between railwalking and ataxiagraph scores, however a close relation existed in the ataxiagraph test scores between the eyes open and eyes closed. Travis[31] also tested body sway with his ataxiameter, a similar device using a helmet and recording the subject's movement. He also tested his subjects on the stabilometer, an unstable platform with a stylus attached that moved over a brass target. The score was kept by electric counters, and any unsteadiness

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[30]Bruce M. Fisher, James E. Birren and Alan L. Leggett, "Standardization of Two Tests of Equilibrium - Railwalking, and Ataxiagraph," <u>Journal of Experimental Psychology</u>, 35:321-329, August, 1945.

[31]Roland C. Travis, "An Experimental Analysis of Dynamic and Static Equilibrium," <u>Journal of Experimental Psychology</u>, 35:216-234, June, 1945.

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[70] Bruce R. Fisher, [illegible] Leggett, "Standardization of Two Tests of [illegible], Railwalking, and Ataxiagraph," Journal of Experimental Psychology, 35:[illegible], [illegible].

[71] Roland C. Travis, "An Experimental Analysis of Dynamic and Static Equilibrium," Journal of Experimental Psychology, 35:[illegible], [illegible], 1945.

in excess of two degrees broke the circuit and interrupted the score. He tested college men and women and concluded that: weight is of great importance and height of little importance in stabilometer performance as determined by controlling height and varying weight and likewise controlling weight and varying height. However weight and height have no bearing on the ataxiameter scores. A small sex difference was found in favor of women in stabilometer performance with weight controlled. He also stated, "Both static and dynamic equilibrium are aided greatly when visual cues are present".[32]

III. LITERATURE ON KINESTHESIS AND BALANCE

Several studies have been made using the stick balance test. Scott[33] used the stick balance test and the balance leap in a battery of twenty-eight tests, to measure kinesthesis. She tested one hundred college women in the first sampling, with eighteen to twenty years the predominate age. The second sampling consisted of seventy college women tested in a battery of sixteen tests. Reliability was adequate, however, no single test could

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[32] Ibid.

[33] M. Gladys Scott, "Measurement of Kinesthesis," Research Quarterly, 26:324-341, October, 1955.

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[32] Ibid.

[33] M. Gladys Scott, "Measurement of Kinesthesis," Research Quarterly, 26:324-341, October, 1955.

be used alone. Scott states:

> A balance test shows up favorably in every study that has been made with a balance test included. Whether this means that the neural mechanism of balance is similar to that used in other test items or simply that acuity of labyrinthine function parallels proprioceptor function cannot be answered at this time. However it seems advisable to put a balance test into any kinesthesis battery, the two used here have been consistently reliable, and fairly valid.[34]

Roloff[35] tested two hundred college women on the stick balance test and a battery of seven other tests used in Scotts' research. She found a coefficient of multiple correlation of .88 for the following battery of four tests: stick balance, arm raising, weight shifting, and arm circling. Young[36] used a battery of nineteen tests to test kinesthesis of thirty-seven college women in regular physical education classes. Using the Spearman-Brown Prophecy Formula she found reliability coefficients of .73 for the stick balance test crosswise on the stick, and .78 lengthwise on the stick.

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[34] Ibid., p. 337.

[35] Roloff, op. cit., p. 214.

[36] Olive G. Young, "A Study of Kinesthesis in Relation to Selected Movements," Research Quarterly, 16:277-287, December, 1945.

be used alone. [illegible]

> A [illegible] that [illegible] these [illegible] balance [illegible] or [illegible] permit [illegible] at this [illegible] balance [illegible] used here [illegible] fairly valid.

Boldt[4] [illegible]

which balances [illegible] were [illegible]

used in Scotts' research. [illegible]

multiple [illegible]

of four [illegible]

and are [illegible]

tests to [illegible]

in regular [illegible]

man-brown [illegible]

fictions [illegible]

the [illegible]

[illegible], p. 372.

Boldt, op. cit., p. [illegible].

[illegible] Relation to [illegible] 15:277-282, November, 1941.

CHAPTER III

TESTS USED IN THIS STUDY

The static and dynamic balance tests were administered to fifty-three deaf boys and girls. These were matched in age and sex with fifty-three normal hearing boys and girls.

I. STATIC BALANCE TEST

The floor phase, bending over, eyes closed, of the Static Balance Test was demonstrated and explained to each student. Three trials were given on the favored foot. The subject was instructed to stand with his side to the timer, with his weight on the ball of one foot, and the heel off the floor, his trunk bent forward until his head was level with his hips, and then to close his eyes and maintain this position as long as possible. The score was taken by stop watch to the nearest quarter of a second. The watch was stopped after sixty seconds or when balance was lost as indicated by touching the floor in any manner or opening the eyes. The best of three trials was recorded. The first day was used for demonstration and practice. Timed tests were taken the second and third days. All of the students were given time to

[illegible]

The [illegible] to fifty-three [illegible]

matched in age and sex with fifty-three [illegible]

boys and girls.

I. [illegible]

The [illegible], [illegible]

the static balance [illegible]

to each student. [illegible]

foot. The [illegible]

to the floor, [illegible]

and the [illegible]

his [illegible]

eyes and [illegible]

score was [illegible]

a second. [illegible]

when balance was [illegible]

in any [illegible]

trials was [illegible]

[illegible]

and [illegible]

feel confident before testing was begun. Slacks or jeans were worn by the boys and girls at the school for the deaf, gymnasium suits by the junior high students, and street clothes by the senior high students. No attempt was made to standardize the type of shoes worn for the tests. Gymnasium shoes were not available for all of the students at the deaf school.

II. STEPPING STONE TEST OF DYNAMIC BALANCE

Three trials of the stepping stone test were administered to the one hundred and six subjects. The test was explained and demonstrated and each student had an opportunity to familiarize himself with the test. Four sets of targets were taped on the gymnasium floors. The floors were hardwood at the deaf school and concrete covered with vinyl tile at the junior high school. Masking tape was used to make the targets on the floor. The test layout is diagramed in the appendix. The best of three scores was recorded. Directions were followed as defined by Bass:

1. Stand on the right foot in the circle marked (x). This is the starting circle.
2. Leap onto the left foot into circle marked (1). A step counts an error. In landing in the circle observe the following:
   a) Land and stay on the ball of the foot; do not lower the heel.
   b) Land within the circles; do not touch the boundary lines of the circles.
   c) Keep the weight on the landing foot only; do not touch the other foot to floor.

d) Keep the foot in contact with the floor; do not hop.

e) Keep the supporting foot still; do not slide or wiggle it along the floor in the attempt to keep balance.

f) Hold as steady a balance as possible up to but not exceeding, five seconds.

3. Continue leaping into the remaining circles, observing the instructions as given for circle one. Remember that the balance should be kept on the last circle as well as on the first nine, and that the greater the time and the fewer the errors, the better the final score.

4. The final score is total time plus fifty* minus three times the total errors.

It is best not to overtire on any one circle for this usually lessens the balance on the next circle. A consistent three-second hold gives a better score than a five-second hold with a number of errors followed by a one- or two-second hold.[37]

The students practiced on three of the four targets. The remaining target was used for testing only. One stop watch was used to test both static and dynamic tests. Different stop watches were used however to test the deaf and the hearing groups.

III. AUDIOMETER TEST

Audiometer test scores were available for all of the deaf students at The New Mexico School for The Deaf. These students were tested periodically at the school. The junior and senior public high school students were

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[37]Bass, op. cit., p. 36.

*Fifty points were required to eliminate minus scores in Bass's data. Seventy points were required for the data of this study.

d) [illegible] not hot.

e) Keep the [illegible] or weight [illegible] balance.

f) Hold [illegible] balance [illegible] but not [illegible].

3. Continue [illegible] observing [illegible] Remember [illegible] circle [illegible] greater [illegible] the third [illegible].

4. The final [illegible] three [illegible].

It is [illegible] this [illegible] A complete [illegible] than a [illegible] followed by a [illegible].

The [illegible]

The [illegible] watch was used [illegible] Different [illegible] deaf and the [illegible].

[illegible]

[illegible] the deaf [illegible] These [illegible] The [illegible]

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[20] [illegible]

[illegible] in Sara's [illegible] of this study.

given audiometer tests in connection with the school health appraisal. Students with a hearing loss were removed from the latter population to be tested.

CHAPTER IV

ANALYSIS AND DISCUSSION OF THE DATA

Dynamic and static balance test scores were recorded for twenty-four deaf and twenty-four hearing boys, and for twenty-nine deaf and twenty-nine hearing girls. Forty-two boys and girls were in the eleven and twelve year age group, thirty-two boys and girls in the thirteen and fourteen year age group, and thirty-two boys and girls in the fifteen and sixteen year age group.

Thirteen of the deaf students were born deaf and eighteen became deaf from infectious causes. The causes of deafness of the remaining twenty-two were unknown.

I. PROCEDURE

The static balance test scores were compiled into various groupings for comparison. All scores were treated as ungrouped data. The individual scores in each classification, deaf and hearing, were squared and the scores and squared scores were totaled to determine the total sum of squares. The formula:

$$\sum_{1}^{n} (X-\bar{X})^2 = \sum_{1}^{n} X^2 - \frac{(\sum_{1}^{n} X)^2}{n}$$

[illegible]

ABILITY [illegible]

Dynamic and [illegible]

recorded for twenty-[illegible] and [illegible]

boys, and for twenty-[illegible]

girls. Forty-[illegible] boys and [illegible]

twelve year age group, [illegible]

thirteen and fourteen year [illegible]

and girls in the [illegible]

Thirteen of the [illegible]

eighteen because [illegible]

of deafness of the remaining [illegible]

The [illegible]

various groupings [illegible]

as ungrouped [illegible]. The individual [illegible]

fication, [illegible]

and squared scores [illegible]

of squares. The [illegible]

$$\sum (X-\bar{X})^2 = \sum X^2 - \frac{(\sum X)^2}{N}$$

was used in which $\overline{x}$ represents the mean of the combined distribution, x each of the scores, and n the total number of observations.

The next step was to determine the sum of the squares within each group. The formula used in analyzing the ungrouped scores was:

$$\sum_{1}^{n_i} (x-\overline{x}_1)^2 + \sum_{1}^{n_i} (x-\overline{x}_2)^2 = \sum_{1}^{K} \sum_{1}^{n_i} (x-\overline{x}_i)^2$$

The sum of these two groups is a measure of the individual observations about the means of the particular groups to which they belong.

The next step was to determine the sum of squares between groups. The formula used was:

$$n_i d_i^2 = \sum_{1}^{K} n_i (x_i - \overline{x})^2$$

The sum of the squares within groups plus the sum of squares between groups is equal to the total sum of squares.

Edwards states:

> Each of the sums of squares has associated with it a specified number of degrees of freedom. For the total sum of squares, we already know that the degrees of freedom will be equal to $n-1$. The number of degrees of freedom within each group is equal to $n_i - 1$, where n_i is the number of observations in each group. But, since we have more than one group, the number of degrees of freedom for the sum of squares within groups will be equal to $K(n_i - 1)$, where K is the number of groups. The number of degrees of freedom

was used in which $\bar{X}$ represents the [illegible] of the com-
bined distribution, represented [illegible] between [illegible] and the
total number of observations.

[illegible] degrees of freedom [illegible] the sum of
squares within groups [illegible]
the sum of squares was

$$\sum (X-\bar{X}_1)^2 + \sum (X-\bar{X}_2)^2 \ldots \sum (X-\bar{X}_k)^2$$

The sum of [illegible] from the means of the respective
observations was to the mean of the respective group
to which they belong.

The next step was to find the sum of squares between groups. The formula was

$$\sum n_k (\bar{X}_k - \bar{X})^2$$

The sum of the squares within groups and the sum of
squares between groups is equal to the total sum of
squares.

Degrees of freedom

Each of the groups [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

for the sum of squares between groups will be equal to $K-1$, where K is the number of groups.[38]

The sum of the squares within groups was divided by its degrees of freedom. This gave an estimate of the common population variance, independant of the variation in the group means. The sum of the squares between groups was divided by its degrees of freedom giving the second estimate of the common population variance, that was independant of the variation within groups. These estimates were then called the mean squares. To obtain the F-score, the larger estimate of the two population variances was divided by the smaller.

To determine whether this value was significant at the 1 per cent level of confidence, Snedecor's Table of Per Cent Points for the Distribution of F, was consulted.[39]

II. ANALYSIS

The difference between the static balance scores of deaf and hearing boys was not significant at the 1 per cent level of confidence. However, Table I indicates that hearing girls were significantly superior

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[38] Allen L. Edwards, Statistical Methods for the Behavioral Sciences (New York: Rinehart and Company, 1954), p. 320.

[39] Ibid., pp. 504-07.

for the sum of squares [illegible] to k-1, where [illegible]

The [illegible] divided by its degrees of freedom. [illegible] common population [illegible] in the population [illegible] groups [illegible] method [illegible] was independent [illegible] estimates [illegible] the F-score [illegible] variance [illegible]

To determine [illegible] at the 1 per cent level [illegible] of Per Cent [illegible] consulted.[3]

II. RESULTS

The [illegible] of [illegible] 1 per cent level of [illegible] indicates [illegible]

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[2]Allen L. Edwards, *Statistical Methods for the Behavioral Sciences* [illegible] p. 320.

[3]Ibid., pp. [illegible]

TABLE I

STATIC BALANCE TEST MEAN SCORES
OF DEAF (D) AND HEARING (H)
BOYS AND GIRLS WITH
THEIR F RATIOS

Groups Compared	Number	Deaf Mean	Hearing Mean	F Ratio
Boys D	24	2.29		
Boys H	24		2.96	3.77
Girls D	29	1.51		
Girls H	29		2.72	17.3 *
Girls D	29	1.51		
Boys H	24		2.96	15.60 *
Girls H	29		2.72	
Boys D	24	2.29		.752
Girls D	29	1.51		
Boys D	24	2.29		3.96
Girls H	29		2.72	
Boys H	24		2.96	.276
Total D	53	1.86		
Total H	53		2.83	10.85 *

*This indicates a significant difference at the 1 per cent level of confidence.

to the deaf girls. A difference was found between deaf girls and hearing boys that was significant at the 1 per cent level of confidence and was in favor of the boys. Statistically there were no significant differences in static balance ability between hearing girls and deaf boys; between the deaf girls and deaf boys; or between hearing girls and hearing boys in their static balance scores. This does not support the findings that males are superior to females as reported by Morsh,[40] Myklebust,[41] or Cron and Pronko[42] from tests on the balance beam or balance platform.

A difference was found between the deaf boys and deaf girls when compared to hearing boys and hearing girls that was significant at the 1 per cent level of confidence and was in favor of the hearing boys and hearing girls. Long[43] also found the deaf inferior to the hearing when tested on the balance beam.

Table II shows the dynamic balance test scores made by the deaf and hearing boys and girls. There was a difference between deaf boys' and Hearing boys' scores that was significant at the 1 per cent level of confidence and was in favor of the hearing boys. Likewise, the hearing

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[40]Morsh, loc. cit. [41]Myklebust, loc. cit.

[42]Cron and Pronko, loc. cit. [43]Long, loc. cit.

to the deaf girls, [illegible] was [illegible] hearing girls and hearing [illegible] cent level of [illegible]. Statistically there [illegible] stable balance [illegible] boys; between the [illegible] hearing girls and [illegible] scores. This does not [illegible] are superior [illegible] or Orom and Shuman [illegible] balance platform.

[illegible] difference [illegible] deaf girls [illegible] that was significant [illegible] and was in favor of [illegible]. Long[43] also found the [illegible] tested on the balance [illegible].

Table II shows the [illegible] by the deaf and [illegible]. difference between deaf [illegible] was significant at the [illegible] was in favor of the [illegible]

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[40] [illegible]

[43] [illegible]

TABLE II

DYNAMIC BALANCE TEST MEAN SCORES
OF DEAF (D) AND HEARING (H)
BOYS AND GIRLS WITH
THEIR F RATIOS

Groups Compared	Number	Deaf Mean	Hearing Mean	F Ratio
Boys D	24	55.95		
Boys H	24		81.37	16.9 *
Girls D	29	52.38		
Girls H	29		80.17	24.28 *
Girls D	29	52.38		
Boys H	24		81.37	31.40 *
Girls H	29		80.17	13.24 *
Boys D	24	55.95		
Girls D	29	52.38		
Boys D	24	55.95		.379
Girls H	29		80.17	
Boys H	24		81.37	.065
Total D	53	54.00		
Total H	53		80.17	38.55 *

*This indicates a significant difference at the 1 per cent level of confidence.

girls scored better on the dynamic balance test than the deaf girls. A significant difference was found between the groups that was significant at the 1 per cent level of confidence. Also the hearing boys surpassed the deaf girls in dynamic balance test scores by an amount that was significant at the 1 per cent level of confidence. A significant difference existed at the 1 per cent level of confidence between dynamic balance scores of the hearing girls and the deaf boys and was in favor of the hearing girls. This differed from the static test in which the difference between these groups was not significant. As in the static balance test, deaf girls and deaf boys show no significant difference in performance in the dynamic balance test. Likewise no significant difference existed between the scores of hearing girls and hearing boys in this test. A large and significant difference was found between the hearing boys' and girls' dynamic balance scores when compared to the deaf boys' and girls' scores. The hearing group was superior in performance. In each group where dynamic balance scores for the deaf and hearing were compared, the hearing were superior to the deaf. Sex differences within the two groups were small and not significant. Here again the findings of this study support those of Long.[44]

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[44] *Ibid.*

Comparisons by age group for static balance scores are presented in Table III. Eleven and twelve year old deaf and hearing boys show no significant difference in static balance scores. Eleven and twelve year old deaf and hearing girls also show no significant difference in this test. Thirteen and fourteen year old deaf and hearing boys compared favorably to each other as did thirteen and fourteen year old deaf and hearing girls, neither varying significantly in their performance in the static balance test.

Statistically there was no difference between fifteen and sixteen year old deaf and hearing boys in the static balance test scores. However a significant difference was found between the static balance test scores of the fifteen and sixteen year old deaf and hearing girls. The hearing girls were superior to the deaf girls. There was some evidence to show ability increased with age for deaf boys and girls. Myklebust,[45] Espenschade, Dable, and Schoendube,[46] Riley,[47] and Cron and Pronko[48] reported similar trends in their studies.

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[45] Myklebust, loc. cit.

[46] Espenschade, Dable, and Schoendube, loc. cit.

[47] Riley, loc. cit.

[48] Cron and Pronko, loc. cit.

Comparisons by age groups of [illegible]

are presented in Figure 1[illegible]. [illegible]

deaf and hearing boys were [illegible]

static balance [illegible]

and hearing girls also showed significant differences

in this test. [illegible]

hearing boys [illegible]

thirteen and fourteen years [illegible]

neither varying significantly [illegible]

the static balance test.

Statistically [illegible]

fifteen and sixteen years [illegible]

static balance [illegible]

difference was [illegible]

scores of the [illegible]

ing girls. The [illegible]

girls. There was [illegible]

with age for the boys and girls. [illegible]

Dahle, and [illegible],[47] [illegible][48]

reported similar [illegible].

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[45] [illegible], op. cit.

[46] [illegible]

[47] [illegible], op. cit.

[48] [illegible], op. cit.

TABLE III

STATIC BALANCE TEST MEAN SCORES
OF DEAF AND HEARING CHILDREN
AT VARIOUS AGES WITH
THEIR F RATIOS

Groups Compared	Number	Deaf Mean	Hearing Mean	F Ratio
Boys 11-12 years	20	1.70	2.05	1.25
Girls 11-12 years	22	1.25	2.57	3.96
Boys 13-14 years	14	1.71	4.28	5.58
Girls 13-14 years	18	1.53	2.06	1.56
Boys 15-16 years	14	3.71	2.93	.384
Girls 15-16 years	18	1.81	3.58	9.81 *
Total	106			

*This indicates a significant difference at the 1 per cent level of confidence.

Dynamic balance scores of deaf and hearing children by age group, are shown in Table IV. A significant difference was found between eleven and twelve year old deaf and hearing boys that was in favor of the hearing boys. Eleven and twelve year old deaf and hearing girls also showed a significant difference in their mean performance in the dynamic balance test. Hearing girls were superior to the deaf girls. The hearing boys, age thirteen and fourteen, do much better than the deaf boys of the same age in the dynamic balance test. There was a significant difference between the performance of the two groups. Likewise thirteen and fourteen year old hearing girls were superior to thirteen and fourteen year old deaf girls. However no difference existed between fifteen and sixteen year old deaf and hearing boys. The means of the two groups were similar. Fifteen and sixteen year old deaf and hearing girls show no difference in dynamic balance ability when compared to each other. As in the static balance test scores deaf boys showed some increase in ability as age increased.

Also of interest were the comparisons made between the causes of deafness and two tests of balance. "Congenital deaf" included boys and girls of eleven through sixteen years of age, that were born deaf. "Infectious group" consisted of boys and girls of the same age group

Dynamic balance scores of deaf and hearing subjects, by age group, are shown in Table IX. A significant difference was found between eleven and twelve year old deaf and hearing boys, that favored the hearing boys. Eleven and twelve year old deaf and hearing girls also showed a significant difference in their performance in the dynamic balance test. The hearing girls were superior to the deaf girls. Hearing boys, thirteen and fourteen, did much better than the deaf boys of the same age in the dynamic balance test. There was a significant difference between the performance of the two groups. Likewise thirteen and fourteen year old hearing girls were superior to thirteen and fourteen year old deaf girls. However no difference was found between fifteen and sixteen year old deaf and hearing boys. The means of the two groups were similar. Fifteen and sixteen year old deaf and hearing girls showed no difference in dynamic balance ability when compared to each other. As in the static balance test, however, all groups showed some increase in ability as age increased.

Limited interest was shown in the comparison of the causes of deafness and the tests of balance. "Congenital deaf" included boys and girls, from eleven through sixteen years of age, that were born deaf. "Adventitious group" consisted of boys and girls in the same age group

TABLE IV

DYNAMIC BALANCE TEST MEAN SCORES
OF DEAF AND HEARING CHILDREN
AT VARIOUS AGES WITH
THEIR F RATIOS

Groups Compared	Number	Deaf Mean	Hearing Mean	F Ratio
Boys 11-12 years	20	51.30	84.3	10.17 *
Girls 11-12 years	22	47.54	86.18	21.84 *
Boys 13-14 years	14	54.00	89.14	10.46 *
Girls 13-14 years	18	46.11	73.55	8.62 *
Boys 15-16 years	14	67.43	69.43	.012
Girls 15-16 years	18	64.55	79.44	1.64
Total	106			

* This indicates a significant difference at the 1 per cent level of confidence.

who became deaf because of measles, scarlet fever, whooping cough, spinal meningitis, or ear infections. These two groups were compared for static balance ability. The congenital deaf scored a mean of 2.37 while the infectious deaf scored a mean of 1.53. This difference proved not to be significant. On the dynamic balance test the congenital deaf mean was 52.31 whereas the infectious deaf mean was 54.17. The difference between the means was not significant. Myklebust,[49] and Padden[50] reported the meningetic deaf group markedly inferior to groups deaf by other causes. Only two students tested were meningetic deaf at the New Mexico School for The Deaf, a population too small to consider as a group.

It should be remembered that balance is maintained by a combination of mechanisms. Although it has been shown that the deaf have inferior balance the physical basis of the inferiority may vary from case to case. Some children may have partially compensated for loss in one balance mechanism by greater development of another. Some deaf children are 'protected' by their families or excluded by their playmates from activities which might help them to develop to their greatest balance potential. These facts must be considered in any interpretation of the data presented.

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[49]Myklebust, Loc. cit. [50]Padden, loc. cit.

who became deaf because of meningitis [illegible] cough, spinal [illegible]. [illegible] groups were [illegible] congenital [illegible] deaf scored [illegible] be significant. [illegible] congenitally deaf mean was 51.[illegible] 54.17. The difference [illegible] Myklebust, [illegible] and [illegible] group [illegible] Only two [illegible] Mexico School for the Deaf, [illegible] consider as a group.

It should be remembered [illegible] by a combination [illegible] shown that [illegible] basis of the [illegible] children [illegible] balance mechanism [illegible] deaf children [illegible] cluded by [illegible] them to develop [illegible] facts must be [illegible] presented.

[illegible]

CHAPTER V

SUMMARY AND CONCLUSIONS

I. SUMMARY

The Stepping Stone Test of Dynamic Balance and the floor phase of the Static Balance Test were chosen after a study was made of the various tests of balance. Twenty-four deaf boys and twenty-nine deaf girls at The New Mexico School for The Deaf in Santa Fe, New Mexico, were tested on the two measures of balance. A matching group in sex and age of normal hearing boys and girls were then tested. The data were separated into various groups, forty-two boys and girls were in the eleven and twelve year age group; thirty-two boys and girls in the thirteen and fourteen year age group; and thirty-two boys and girls in the fifteen and sixteen year age group. Thirteen of the deaf students were born deaf, eighteen became deaf from infectious causes, the causes of deafness of the remaining twenty-two were unknown. Analysis of Variance was used to compare the groups. Tables I, II, III, and IV, show the F ratios.

II. CONCLUSIONS

For the groups studied in this investigation it

[illegible]

[illegible]

[illegible]

The [illegible] [illegible] [illegible]
the [illegible] [illegible] [illegible]
after [illegible] [illegible]
Twenty-four [illegible] twenty-[illegible] [illegible]
[illegible]
[illegible]
group [illegible]
were [illegible]
[illegible]
twelve [illegible]
thirteen [illegible]
and [illegible]
Fourteen [illegible]
[illegible]
of the [illegible]
Variance [illegible]
III, and IV, [illegible]

[illegible]

[illegible]

may be concluded that:

1. There is no difference between the congenital and infectious deaf groups in dynamic and static balance test scores.

2. Hearing girls are superior to deaf girls in both dynamic and static balance test scores.

3. Hearing boys are superior to deaf boys in the dynamic balance test.

4. Deaf boys do not differ significantly from hearing boys in static balance test scores.

5. Hearing girls are superior to deaf boys in the dynamic balance test.

6. Hearing boys are superior to deaf girls in the dynamic balance test.

7. As a group the hearing boys and girls are significantly different from the deaf boys and girls in both dynamic and static balance test scores. These differences are in favor of the hearing boys and girls.

8. The deaf boys' and the deaf girls' mean scores indicate an increase in ability with age from the eleven and twelve year age group through the fifteen and sixteen year age group for the static balance test.

9. The deaf boys' mean scores indicate an increase in ability with age for the dynamic balance test.

10. Dynamic balance ability does not increase with

may be concluded that:

1. [illegible]

and infantile [illegible] test section.

2. [illegible]

both dynamic and [illegible]

3. [illegible]

dynamic balance [illegible]

4. [illegible]

hearing [illegible]

5. [illegible]

dynamic balance [illegible]

6. [illegible]

dynamic balance [illegible]

7. [illegible]

significantly [illegible]

both dynamic and [illegible]

differences [illegible]

8. [illegible]

indication [illegible]

and twelve [illegible]

year age [illegible]

9. [illegible]

in ability [illegible]

10. [illegible]

age for the deaf girls.

11. There is no evidence to indicate hearing boys and hearing girls dynamic or static balance ability improves with age within this age range.

III. RECOMMENDATIONS

Since it has been shown that significant balance differences exist between hearing and deaf children the following recommendations are offered:

1. Pupils with hearing loss should be tested for balance and appropriate adjustments should be made in their physical education programs.

2. A study should be undertaken to determine the possibility of improving the balance abilities of children with auditory deficiencies.

3. A study relating the balance ability of children to the amount of hearing loss would be of value.

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APPENDIX

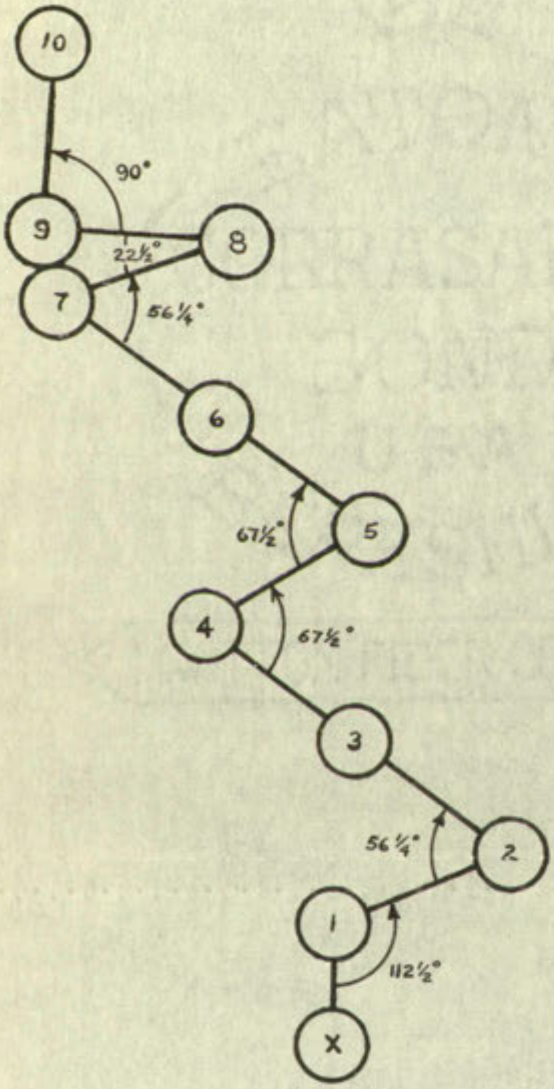

FIGURE 1

Circles eight and one half inches in diameter.

X = starting circle; eighteen inches from X to circle one. Thirty-three inches between all other circles.