The Performance of Children with Down Syndrome on the Bruininks Oseretsky Test of Motor Proficiency

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THE PERFORMANCE OF CHILDREN WITH DOWN SYNDROME ON THE BRUININKS OSERETSKY TEST OF MOTOR PROFICIENCY

By

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THESIS

Submitted to the Department of Physical Therapy at Grand Valley State University Allendale, Michigan in partial fulfillment of the requirements for the degree of

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THE PERFORMANCE OF CHILDREN WITH DOWN SYNDROME ON THE BRUININKS OSERETCKY TEST OF MOTOR PROFICIENCY

ABSTRACT

The purpose of this study was to begin collection of normative data on how children with Down syndrome, that are educable and trainable mentally impaired, perform on the Bruininks Oseretsky Test of Motor Proficiency - Short Form (BOTMP-SF). The researchers collected data on children with Down syndrome between the ages of 4.11 and 13.7. Twenty subjects including 15 males and 5 females volunteered for the study. All participants were from schools and support groups throughout Holland, Grand Rapids, and Muskegon, Michigan. Each child was tested using the BOTMP-SF. Results indicated that children with Down syndrome perform significantly lower than children without Down syndrome on the BOTMP-SF. Comparisons between those participants with and without pre-existing medical conditions were not statistically significant. The researchers concluded that the BOTMP-SF is not an adequate tool to measure the motor skills of children with Down syndrome and recommend the use or development of other tests.
ACKNOWLEDGEMENTS

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CHAPTER 1
INTRODUCTION

Children with Down syndrome (also referred to as Down's Syndrome or Downs Syndrome) are a growing population due to increasing health care provisions and understanding of the disease. There are more children with Down syndrome being integrated into the mainstream school system and mainstream physical education classes. Health care professionals are faced with the task of evaluating children with Down syndrome for gross and fine motor function. This is currently difficult due to the lack of standardized measurements to test motor function. One popular test for motor function in normal children is the Bruininks Oseretsky Test of Motor Proficiency (BOTMP). The BOTMP currently has no normative data for children with Down syndrome. This information would be useful to health care providers and school systems in evaluation and placement of children with Down syndrome.

The BOTMP was established in 1978 by Robert H. Bruininks. (Bruininks, 1978). The standardized test was designed to evaluate gross and fine motor skills of children, ages four and a half to fourteen and a half. There are eight subtest areas incorporated into the BOTMP including: running speed and agility, balance, bilateral
coordination, strength, upper limb coordination, response speed, visual motor control, and upper limb speed and dexterity.

The BOTMP is used by many different professionals as an assessment, evaluative, and descriptive tool (Miles, Nierengarten, Nearing, 1988; Wilson, Polatajko, Kaplan, & Faris, 1995). Medical professionals utilize the test as a means of evaluating and determining goals for the individuals being tested. School systems use the BOTMP to determine the most appropriate physical education option for each student.

In reviewing the literature the researchers found no pre-existing normative data on children with Down syndrome using the BOTMP or the Bruininks Oseretsky Test-Short Form (BOTMP-SF). According to many researchers there is a large deficit in the area of normative data for children with specific disabilities such as Down syndrome (Miles, Nierengarten, Nearing, 1988; Henderson, Morris, Ray, 1981; Spiegel, Steffens, Rynders, Bruininks, 1990). The qualities inherent in most children with Down syndrome have been correlated with lower scores of performance on the BOTMP when compared to normative scores already compiled for children with Down syndrome (Connolly, Michael, 1986).

Problem Statement

The problem is the lack of normative values for children with Down syndrome on the BOTMP from which to evaluate and progress the treatment of these children.
Hypothesis

Children with Down syndrome, that are educable and trainable mentally impaired, will perform lower than the established normative values as indicated in the BOTMP examiner's manual. The significance will be set at a p-value of 0.05.

Purpose of the Study

The purpose of the study is to determine a beginning level of normative data on how children with Down syndrome, that are educable and trainable mentally impaired, perform on the BOTMP-SF.

Aims of the Study

1) provide physical therapists, and other professionals that may utilize the BOTMP, with initial values of normative data for the performance of children with Down syndrome on the BOTMP-SF.

2) determine initial normative data for the performance of children with Down syndrome on the BOTMP-SF that in the future, with additional data collection, may be used to develop standardized normative values.

3) determine any relationships or correlations as to how children with Down syndrome having certain pre-existing conditions perform compared to one another on the BOTMP-SF.

4) quantify the difference between the scores of children with Down syndrome and the normative data already developed by Bruininks for the performance on the BOTMP-SF.
It is important to recognize and comprehend maximum potential for children with Down syndrome in order to facilitate the highest quality of life and education (Wilson, Polatajko, Kaplan, 1995). The integration of children with Down syndrome into the school systems and an increased awareness of the unique needs of this population confirm the need for a valid means to measure their motor skill and development. The development of standardized norms for this population would facilitate the use and increase the benefits of the BOTMP.

Definition of Terms

1) BOTMP: The Bruininks Oseretsky Test of Motor Proficiency.
2) BOTMP-SF: The Bruininks Oseretsky Test of Motor Proficiency-Short Form.
3) Down Syndrome: a chromosomal abnormality of the 21st chromosome resulting in varying degrees of mental retardation, hypotonia, and other characteristics unique to this condition.
4) Educable mentally impaired: IQ 70-50.
5) Trainable mentally impaired: IQ 49-35.
6) Severely mentally impaired: IQ 34-20.
7) Profoundly mentally impaired: IQ 20-0.
CHAPTER 2

LITERATURE REVIEW

The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) was developed by Dr. Robert H. Bruininks and was completed in 1978. The test was originally designed to assess the motor functioning of children from 4.5 to 14.5 years of age. Bruininks (1978) stated that the BOTMP was, "developed to provide educators, clinicians, and researchers with useful information to assist them in assessing motor skills of individual students, in developing and evaluating motor training programs, and in assessing serious motor dysfunctions and developmental handicaps in children" (p. 11). According to a survey of more than 20 treatment centers, the BOTMP was one of the five most commonly used tests of motor function (Wilson, Polatajko, Kaplan, & Faris 1995). An introduction to the BOTMP and related literature will be followed by a review of Down syndrome.

There are eight subtests of the BOTMP-SF; four measure gross motor skills, three measure fine motor skills, and one measures a combination of gross and fine motor skills. The subtests are listed as follows (Bruininks, 1978):

Gross Motor Skills:

1. Running Speed and agility: measures running speed during a shuttle run.

2. Balance: measures static balance using standing on one leg activities.

   Dynamic balance is measured while executing selected walking activities.
3. **Bilateral Coordination**: measures coordination of simultaneous upper and lower limb activity.

4. **Strength**: measures arm, shoulder, abdominal, and leg strength

**Fine Motor Skills:**

5. **Response Speed**: measures the ability to respond quickly to a moving visual stimulus.

6. **Visual-Motor Control**: measures the ability to coordinate hand and visual movements.

7. **Upper-Limb Speed and Dexterity**: measures hand and finger dexterity, and hand and arm speed.

**Gross and Fine Motor Skills:**

8. **Upper-Limb Coordination**: measures coordination of visual tracking and precise movements of the arms, hands, or fingers.

If one were to administer the complete battery, which includes all of the gross, fine, and combination tests, there would be composite scores that could be combined to yield a battery composite score. The subtests 1-4 and 5-8 can be given to acquire an index of gross or fine motor proficiency, respectively.

Bruininks suggested using the BOTMP-SF for testing large groups of children (Bruininks, 1978). It provides the tester with an index of general motor proficiency. Broadhead and Bruininks (1982) reported that moderately and severely mentally retarded children can perform and score on the short form test items. Their study also showed that the BOTMP-SF was sufficiently sensitive to measure motor proficiency.
over time (Broadhead & Bruininks, 1982). They recommended that the BOTMP-SF be used as part of a multi-disciplinary evaluation and that it could be of significance in the annual assessment that is done to plan the intermediate and long-term curriculum needs of children with handicaps (Broadhead & Bruininks, 1982). A study was done by Verderber and Payne (1987) to compare the long and short forms of the BOTMP. The Pearson product-moment $r$ values indicated a strong relationship between long and short form scores when the data was converted to standard and percentile scores (Verderber & Payne, 1987). The results of this study indicated that if a subject scores high on the short form in relation to the other subjects they would score high on the long form when compared to the other subjects. See Appendix A to review the BOTMP-SF in its entirety.

Bruininks (1978) recommends several uses for the BOTMP. It can aid educators in the placement of children into programs that require a predetermined level of motor skill performance, such as physical education class or even kindergarten. The use of the BOTMP by physical therapists and educators in strictly assessing the gross and fine motor skills of children is applicable as well. It is conducive to the development and evaluation of motor training programs that are frequently being used to benefit children with academic and motor skill deficiencies. Results of the BOTMP can be beneficial to those individuals that are developing a physical education or motor development curriculum. For example, the BOTMP can assess motor skills before instruction so that the teacher can gear the lessons to the students skill level, group students by their motor ability, and assess the effectiveness of given instruction and
how well the learners can generalize the knowledge to other situations (Bruininks, 1978).

Bruininks (1978) remarks that, "increased attention is being given to the identification of physical, mental, social, and emotional problems in children" (p. 15). The BOTMP can be used in clinical settings as a screen for motor skill deficiencies. It was designed to measure neurological development in children and adolescents and can be used by clinicians to make observations of performance and aid in the development of hypotheses regarding a differential diagnosis (Bruininks, 1978).

Wilson et al. (1995) conducted a study to investigate the use of the BOTMP in occupational therapy. The study included an in depth review of the BOTMP. These researchers concluded, after reviewing the results of three studies that used the BOTMP, that it was an effective tool for identifying children with and without learning disabilities for treatment programs and the identification of treatment goals (Wilson et al, 1995). This same study went on to analyze the use of the BOTMP as a evaluative instrument. To use the BOTMP as an evaluative tool, the tester should compare a child's performance to his/her previous performance. Wilson et al. (1995) suggested that comparing a child's performance and improvement over time to the normative values may not accurately represent a change because the normative scores on the BOTMP are based on a group of children without motor delays.

The development of the BOTMP has an interesting history. Bruininks based his test on the United States adaptation of *The Oseretsky Tests of Motor Proficiency* (Bruininks, 1978). He used roughly 30 of the 60 test items for the Oseretsky test and
added 70 items. All of the test items met strict criteria developed by Bruininks that would guarantee adequate coverage of the areas which the test would measure. The final edition of the BOTMP contains 40 percent of the original Oseretsky test, and the remainder was created by Bruininks (Bruininks, 1978.)

To standardize the BOTMP, the following areas were considered for the development of a sample group: age, sex, race, community size, and geographic region. A total of 765 subjects from five geographic regions were given the test in the spring and fall of 1973 (Bruininks, 1978). The Short Form of the Bruininks-Oseretsky was developed from the data gathered during the standardization program. The BOTMP-SF provides a general estimate of motor development.

The scores that were compiled from the standardization process were expressed in ways that made it impossible to add the scores up and have a composite score. Thus, a point score conversion system was developed. The standard scores for the subtests were developed by taking the means and standard deviations from each subtest for each age group in the standardization program. This information was taken through a battery of statistics and resultant norms for the subtest scores were developed. The composite standard scores from the standardization program were also taken through similar statistical analysis to result in the development of norms for the composite scores (Bruininks, 1978).

"The validity of the Bruininks-Oseretsky Test is based on its ability to assess the construct of motor development or proficiency" (Bruininks, 1978, p.28). The relationship of test content to significant aspects of motor development was one aspect
upon which the construct validity of the BOTMP was considered. Other areas included
the relevant statistical properties of the test and the functioning of the test with
contrasting groups of handicap and non-handicapped children (Bruininks, 1978).

Bruininks investigated the work of Guilford (1958), Cratty (1967, 1970),
Fleichman (1964), Harrow (1972), and Rarick and Dobbins (1972) to determine if the
BOTMP tested motor development and related aspects that were considered
significant by these researchers. Upon careful consideration and comparison to these
studies, Bruininks (1978) found that the BOTMP was judged to be significant for
measuring motor development by the standards of these named researchers and their
erp任期 expertise in the field of motor development and proficiency. Bruininks and his peers
now use the BOTMP to investigate the use of other tests of motor proficiency. The
early motor profile was developed as a result of a review and analysis of the BOTMP
(Spiegal, Steffens, Rynders, & Bruininks, 1990). The content of the profile is aimed at
testing children from the age of 2 to 7 and identifying those that may have or are at
risk of developing disabilities (Spiegal et al., 1990).

The following three areas of discussion on statistical characteristics
demonstrated the construct validity of the BOTMP. First, there was the relationship of
the test scores to chronological age. Bruininks (1978) hypothesized that the mean
point scores on each subtest would correlate with chronological age level and thus
increase at successive age levels. A correlation median of .78 indicated that a close
relationship does exist between subtest scores and chronological age (Bruininks,
1978). The second area of focus with respect to construct validity was the internal
consistency of the subtests. The BOTMP resulted in a higher correlation between the item being tested and the subtest score versus the item being tested and the total test score (Bruininks, 1978). However, Hattie and Edwards (1987), found that, in addition to the existing gender differences, the item consistency within the subtest was low. Finally, a factor analysis was performed on the 46 items that were taken from the standardization sample. This was done to clarify the underlying structure of the BOTMP and to statistically support the grouping of the items into subtests (Bruininks, 1978).

Three studies were performed to test the hypothesis that mentally retarded and learning disabled subjects would score lower on the BOTMP than subjects without these conditions of the same sex and age from the same size community (Bruininks, 1978). The results of these studies support the underlying purpose of this study. A t-test for the independent means was utilized on the performance scores of subjects with and without mental retardation and learning disabilities. The first study compared children with mild retardation and children that were not retarded. The 72 subjects with mild retardation ranging in age from 5 years, 11 months to 14 years and with IQ's ranging from 61 to 75 were enrolled in special classes. The other 72 subjects ranged in age from 5 years, 9 months to 14 years, 1 month. The t-test for differences between the mean scores on the eight subtests, the three composites, and the Short Form were all statistically significant and would occur by chance less than one time in 100 (Bruininks, 1978). Bruininks (1978) stated, "these results confirm the hypothesis that
normal subjects perform significantly better than mildly retarded subjects of the same chronological age on all parts of the Bruininks-Oseretsky Test" (p. 31).

The second study done to test this hypothesis was a comparison of moderately-to-severely retarded children to children termed 'normal' by Bruininks (Bruininks, 1978). The 19 subjects, with moderately-to-severe mental retardation ranged in age from 6 years, 2 months to 13 years, 7 months with IQ's ranging from 29 to 50, also attended special schools. The other subject group consisted of 19 children ranging in age from 6 years, 2 months to 10 years, 1 month. Again, the t-test for the differences between the mean scores on the eight subtests, the three composites, and the Short Form were all statistically significant and would be expected to occur by chance less than one time in 1000 (Bruininks, 1978). Bruininks (1978), therefore, could state that, "these results confirm the hypothesis that normal subjects perform significantly better than moderately-to-severe retarded subjects of the same chronological age on all parts of the Bruininks-Oseretsky Test" (p. 31).

The third study of relevance to this study was a comparison of learning disabled with normal subjects (Bruininks, 1978). There were 55 subjects with learning disabilities that were enrolled in special schools or special education programs. They ranked roughly two years below grade level in reading and also below grade level in mathematics. They ranged in age from 5 years, 8 months to 12 years, 10 months. The other group consisted of 55 subjects ranging in age from 5 years, 10 months to 12 years, 11 months. Once again, the t-tests differences between the mean scores for seven of the eight subtests, the three composites, and the Short Form were statistically
significant (Bruininks, 1978). Subtest 6, Response Speed, did not discriminate between these two groups being tested (Bruininks, 1978; Wilson et al., 1995). Bruininks (1978) had the opportunity to state again that, "these results confirm the hypothesis that normal subjects perform significantly better than learning disabled subjects of the same chronological age on all parts of the Bruininks-Oseretsky Test except Subtest 6" (p. 34).

Of the three studies that Wilson et al. (1995) reviewed related to the performance of children with learning disabilities and motor deficits, results indicated these children had no problems performing within the identified normal limits on Bilateral Coordination (subtest 3), Strength (subtest 4), Upper Limb Coordination (subtest 5), and Response Speed (subtest 6). However, they did indicate that the children used in the three studies they reviewed did have difficulty with Running Speed and Agility (subtest 1), Balance (subtest 2), Visual Motor Control (subtest 7), and Upper Limb Speed and Dexterity (subtest 8) (Wilson et al., 1995). These researchers could therefore conclude, "that the Running Speed and Agility, Balance, Visual Motor Control, and Upper Limb Speed and Dexterity subtests are likely to provide the greatest degree of discrimination between children with and without motor problems" (Wilson et al., 1995, p. 15). In light of this finding, the question arises, how can the BOTMP be administered and used as an effective and highly useful clinical tool to children who do not fall into categories of developed norms?

Another area of the BOTMP that must be addressed is the test-retest reliability. Bruininks conducted a study to investigate the test-retest reliability of the BOTMP.
The sample consisted of 63 second graders and 63 sixth graders. Both groups took the BOTMP twice within a 7-to-12 day period. The reliability coefficients, used in comparing reliabilities of different test, from this study were .89 for grade 2 and .86 for grade 6, indicating that the BOTMP is a reliable measurement of motor proficiency (Bruininks, 1978). A study of test-retest reliability on the BOTMP conducted by King-Thomas and Hacker (1987) resulted in coefficients ranging from .68 to .88. The subtests for Balance and Response Speed had coefficients below .80 (King-Thomas & Hacker, 1987). These researchers went on to recommend that better reliability was obtained for the total test and short form rather than the subtests individually.

Bruininks (1978) also determined the standard error of measurement (SEm) for each subtest and found that the SEm for the subtests had a mean of 15 and a standard deviation of 5. The composites had 2 or 3 standard score points and 4 or 5 standard score points, which placed their mean at 50 and standard deviation at 10. These results indicated that practice had no major effect on the scores that would be expected with many repeated trials on the test. However, Hattie and Edwards (1987) suggested that the standard errors of measurement were high and could result in difficulty in properly interpreting the scores for Running Speed and Agility, Balance, Upper Limb Coordination, and Response Speed.

There were two studies done to determine the inter-rater reliability of the BOTMP. The eight items of Subtest 7: Visual Motor Control were used because the scoring of this portion of the BOTMP was most subjective and required a high level of interpretation and critique by the testers. To summarize both studies, a total of 8
individuals with no previous training on the administration of the BOTMP tested 104 subjects. The median correlations for the two groups of raters were .98 for study 1 and .90 for study 2 (Bruininks, 1978). These results indicated that the BOTMP can be given by people without formal training and a consistent inter-rater reliability can be achieved (Bruininks, 1978). Wilson et al. (1995) were quick to point out in their study that the, "lack of any examination of inter-rater reliability on the other seven subtests indicates a major limitation of the BOTMP and suggests the need to use the same rater when the test is being readministered" (p. 10). They went on to recommend that the use of the BOTMP was appropriate for the measurement of motor abilities of children, "within the limits of the undefined inter-rater reliability" (Wilson et al, 1995, p.10).

Miles, Nierengarten, and Nearing (1988) conducted a study to review the 11 most often cited assessment instruments used in adapted physical education. They found that of the 300 instruments available to measure motor behavior the BOTMP was, "perhaps the most technically sound test" (Miles et al., 1988, p.35). Bruininks (1978) suggested that the BOTMP has demonstrated it's application in the use of discriminating between children with learning disabilities and those with mild and moderate mental retardation. Miles et al. (1988) recognized the validity of Bruinink's insight and stated that, "a need exists for the development of normative data for other disability groups served by the adapted physical educator" (p. 35), and professionals that share the goal of improving the education and quality of life for children dealing with motor and developmental delays. Public Law 99-457 has expanded services to infants and young children with disabilities. It has also raised the awareness of the
effects of early intervention and how these children would benefit from research and development of tools that relate to motor development and problems associated with it (Spiegel et al., 1990).

Review of Down Syndrome

A thorough review of Down syndrome will lend itself to the foundation of knowledge that will be used to develop the research questions and hypothesis for this study. Down syndrome is an autosomal aberration that results in an extra chromosome 21, thus it is often termed Trisomy 21 (Merck Manual, 1992). Down syndrome occurs about once in every 700 births (Merck Manual, 1992). The Merck Manual (1992) also reported that mothers over the age of 35 have an estimated 7 to 8% of the children born in the United States, yet 20% of these children are born with Down syndrome. Complications during pregnancy, labor, and delivery are seen in about one half of the cases of Down syndrome (McIntire, Menolascino, & Wiley, 1963). These figures may change as the result of an increased number of children being born to women over the age of 35 within the last few years. The mean IQ for children with Down syndrome is on average 50, and there are physical and mental developmental delays (Merck Manual, 1992). Congenital heart defects are found in 35% of patients with Down syndrome, with atrioventricular and ventricular septal defects being the most common (Merck Manual, 1992). The aging process seems to be accelerated in these patients. Heart disease and susceptibility to acute leukemia also effects their prognosis. McIntire et al. (1963), in conjunction with the Mental Retardation Project of the Nebraska Psychiatric Institute, conducted a study to investigate the clinical aspects of
Down syndrome. Of the 616 infants with Down syndrome, all but 2 of them presented with hypotonia, making it the most commonly seen characteristic of the condition (McIntire et al., 1963).

The remainder of this review of Down syndrome will focus more directly on the aspects of the disease that could alter the child's motor performance. The literature revealed the following areas to be factors in the motor performance of children with Down syndrome: their motor development, reaction time, gross motor coordination, hand and eye coordination, laterality, visual motor control, balance, motor planning, hypotonia, postural control, cerebellar size, strength, and the relationship between IQ and motor skill.

Researchers agreed that the motor development of children with Down syndrome is delayed in comparison to children without Down syndrome. In fact, by the age of 13 months, a child with Down syndrome will have a motor delay of up to 4 to 5 months behind that of a 1 year old child without Down syndrome (Connolly & Michael, 1986; Fishier, Share, & Koch, 1964). By the age of 5, a child with Down syndrome will be approximately 2 years behind in motor skill development when compared to a child without Down syndrome (Connolly & Michael, 1986). Janet Carr (1970), a recognized expert in this area, reported the subjects with Down syndrome in her study had, "both mental and motor scale scores significantly below those of the control group at 6 weeks, declined to 10 months and less rapidly after that to 2 years" (p. 217).
These results broadly agreed with those discussed by Dicks-Mireaux (1972) indicating that infants with Down syndrome develop faster between the ages of 3 and 9 months than between the ages of 9 and 18 months. In the Dicks-Mireaux (1972) study, he remarked on his earlier study he did in 1966 that revealed the developmental quotient, which is the mental age divided by the chronological age times 100, "followed a downward trend with increasing age and that this trend was most marked in the area of motor ability" (p. 26). The longitudinal study, conducted by Dicks-Mireaux (1972), further explained the developmental delays of children with Down syndrome by finding that these individuals, "have a mental development significantly below average already at the age of 3 months" and furthermore, "their rate of development is not only slower than the rate of normal infants but shows also a progressive deterioration" (p. 31).

Melyn and White (1973) suggested that the degree of hypotonia, the genetic potential, and the amount of environmental stimulation of the child will all influence early motor development in children with Down syndrome. This study also indicated that development was faster in children that were raised at home rather than in institutions (Melyn & White, 1973). A study conducted by Shumway-Cook and Woollacott (1985) used children with Down syndrome ages 15 months to 6 years and found that they functioned 18 to 24 months behind their age levels in the performance of both static and dynamic balance tests. These results supported the findings of Connolly and Michael (1986) that by the age of 5, motor skills will be delayed by about 2 years in children with Down syndrome.
There are also differences in motor development between the two sexes. The study carried out by Melyn and White (1973) on the mental and developmental milestones of noninstitutionalized children with Down syndrome resulted in data that showed sex differences in sitting, standing, walking, and speaking first words. The females in this study developed these characteristics before the males. Melyn and White dealt with this difference by stating, "this fact cannot be explained by our present data" (p. 544). The results from the study done by Carr (1970), using the Bayley Scales of Infant Development, also supported the differences between males and females with Down syndrome. The females in this study performed significantly higher on the mental scale of the test (Carr, 1970). The females performed only slightly higher than the males on the motor scale portion of the test; it was not statistically significant (Carr, 1970).

An innovative study conducted by LaVeck and LaVeck (1977) also tested children with Down syndrome on the Bayley Scales of Infant Development in hopes of discovering what, if any, differences existed between males and females with Down syndrome. The results of this study were similar to those of the Carr (1970) study, with the exception of the statistical significance of the results being the reverse on the motor and mental scales. The data indicated that females performed better than males on both aspects of the test. The mental scores of the females were not significant for the mental portion, t(38) = 0.97, but were still elevated (LaVeck, B. & LaVeck, J.D., 1977). The motor scores for the females were significantly higher, t(38) = 2.14, p<0.05, than that of the males (LaVeck, B. & LaVeck, J.D., 1977). These researchers
speculated about the possible advantage that females with Down syndrome may have over males with regards to early motor development (LaVeck, B. & LaVeck, J.D., 1977). However, Connolly and Michaels' (1986) study of the performance of retarded children with and without Down syndrome on the BOTMP did not support the findings of Melyn and White (1973) and LaVeck and LaVeck (1977). When the females with Down syndrome were compared to those without, those with the condition did poorer in areas of running speed, balance, strength, visual motor control, and upper limb speed and dexterity. However, when comparing the two sets of males, there was not any significant difference between those with Down syndrome and those without Down syndrome. Thus, for the two groups of children, those with and those without Down syndrome, the females with Down syndrome provided the greatest source of statistical difference for the entire study (Connolly & Michael, 1986).

Reaction time has been shown to be slower in children with Down syndrome when compared to children with mental retardation (Berkson, 1960; Hermelin & Venables, 1964; Henderson, Morris, & Frith, 1981). Frith and Frith (1974) found that when performing on a single-plate tapping task, the children with Down syndrome were slower than children with mental retardation and subjects with normal range IQ's. Results of this study led the researchers to conclude that the inability of the children with Down syndrome to do the requested motor activities was characterized by the inability to develop and use a motor program (Frith & Frith, 1974). They suspected the underdevelopment of the cerebellum to be a factor in this inability to form feedforward motor programmes. Frith and Frith (1974) stated, "feedback requires
They went on to report that children with Down syndrome, "should do relatively well in motor tasks requiring slow movements following no predetermined course but relatively badly at tasks involving fast and regular movements" (Frith & Frith, 1974, p. 299). Seyfort and Spreen (1979) conducted a study aimed at replicating the result of the Frith and Frith (1974) study. They used a two-plate tapping performance test rather than the one-plate performance tapping test utilized in the Frith and Frith (1974) study. Seyfort and Spreen (1979) found there to be no difference between the tapping rate of children with Down syndrome and those without Down syndrome, but those with Down syndrome did make significantly more same plate repetitions and their rate of tapping was at the expense of their failure to alternate between the two plates. They were able to conclude that, "this finding may be interpreted as a deficit in forming or utilizing preprogrammed motor sequences and, therefore, supportive of the Frith and Frith hypothesis" (Seyfort & Spreen, 1979, p.354).

Henderson, Morris, and Frith (1981) conducted a study to investigate what areas of the motor program were affected by Down syndrome. It was their hypothesis that children with Down syndrome would have more difficulty than children with mental retardation on the temporal aspects of performance rather than the spatial aspects. Thus, when "the child is required to complete a sequence of movement in a set time or time his movement to coincide with external events his difficulty would become evident" (Henderson, Morris, & Frith, 1981, p.234). The results of this study showed a
specific motor deficit in motor programming with the children with Down syndrome performing more poorly than children with mental retardation on all temporal aspects of the test activity. Performance on the spatial activities thus proved their hypothesis (Henderson, Morris, & Frith, 1981). These researchers concluded that, "a very subtle deficit in only one aspect of motor control can have far-reaching effects and may be responsible for the slowness typical of so many retarded children and especially those suffering from Down's Syndrome" (Henderson, Morris, & Frith, 1981, p. 244).

The results of a study conducted by Henderson, Morris, and Ray (1981) further supported the findings of Frith and Frith (1974), Seyfort and Spreen (1979), and Henderson, Morris, and Frith (1981). This study looked at the performance of children with Down syndrome on the Cratty Gross-Motor Test. The children with Down syndrome performed more slowly than the control group, especially when a speed criterion was imposed (Henderson, Morris, & Ray, 1981). Thus, for the Gross Agility task, which is a timed event, the children with Down syndrome performed significantly more poorly than the other children (Henderson, Morris, & Ray, 1981).

For example, subtest 3, Bilateral Coordination, item 1, Tapping Feet Alternately While Making Circles with Fingers, is a test of motor planning and the timing of arm and leg movements simultaneously (Fine, 1979).

There are several research studies that support the finding that children with Down syndrome have deficits in eye-hand coordination, laterality and visual motor control (Clausen, 1968; Frith & Frith, 1974; Seyfort & Spreen, 1979; Henderson, Morris, & Frith, 1981; Henderson, Morris, & Ray, 1981). Henderson, Morris, and
Frith (1981) found children were deficient in tasks that required proprioceptive and visual reference systems. Research done by Connolly and Morgan (1993) also demonstrated the deficits in integrating visual and proprioceptive information by children with Down syndrome. They administered the BOTMP to children with Down syndrome and found that they had a difficult time with the visual motor coordination and response time tasks, thus supporting the findings of Henderson, Morris, and Frith (1981) (Connolly & Morgan, 1993). Connolly and Michael (1986) also found that children with Down syndrome performed poorer than children that were mentally retarded on the visual motor control portion of the BOTMP. A very complex study by Davis and Kelso (1982) also investigated motor control and coordination and found, through looking at torque versus joint angle, that the children with Down syndrome were, "less accurate in controlling movements than their age equivalent peers" (p. 209).

The study done by Connolly and Michael (1986) to test children with Down syndrome on the BOTMP showed that balance was another area in which this population has deficits. Henderson, Morris, and Ray (1981) administered the Cratty Gross-Motor test to children with Down syndrome and concluded that the children had particular difficulty with tasks that required good balance. They found that, "very few could hop on one foot and most found moving backwards particularly difficult" (Henderson, Morris, & Ray, 1981, p. 423). The results indicated that 64 percent of the control group of mentally retarded children could balance for 4 seconds and only 35 percent of the group of children with Down syndrome were able to replicate this
performance (Henderson, Morris, & Ray, 1981). The decrease in cerebellar size in
children with Down syndrome and the relationship to hypotonia and function are said
to be a causal factor in their balance deficits. This concept will be addressed later
during the discussion of hypotonia. Much of the ability to balance requires a
feedforward, motor programming type of reaction. As evidenced by Henderson,
Morris, and Frith (1981) and other researchers mentioned in the discussion of motor
planning, children with Down syndrome have a deficit in the ability to motor plan that
could therefore affect their balance performance.

Shumway-Cook and Woollacott (1985) found that young children with Down
syndrome had difficulty maintaining stability secondary to the poor and slow postural
responses to loss of balance. The purpose of their study was to determine if the deficits
in static and dynamic balance skills found in children with Down syndrome are the
result of abnormalities within the automatic postural control system (Shumway-Cool
& Woollacott, 1985). The results of this study questioned the existing literature that
reported delays and balance problems associated with Down syndrome to decreased
segmental motoneuron pool excitability and pathology of the stretch reflex
mechanism that causes hypotonia (Shumway-Cook & Woollacott, 1985). Shumway-
Cook and Woollacott (1985) reported that the onset latencies of the children in their
study "were significantly slower and resulted functionally in increased body sway and,
in some instances, loss of balance" (p. 1320). Their results also indicated normal
myotatic latencies and presence of low level tonic background activity which showed
delayed activation of postural responses. These results can not be attributed to reduced
segmental motorneuron excitability (Shumway-Cook & Woollacott, 1985). Thus, the hypotonia associated with Down syndrome may not be the cause of balance and postural response deficits in children with Down syndrome; it may be defects within the higher-level postural control mechanisms. However, as noted by Connolly, Morgan, and Russell (1984) and other researchers, "hypotonia and the effects of hypotonia, such as decreased pelvic stability and pes planus, are thought to contribute to balance problems" (p. 1518). There was some concern by the researchers of this study and of others that the use of a balance beam in the BOTMP may not validly test balance that is of the type we use in every day activity. In a study done by Depaepe and Ciccaglione (1993), there was some discussion as to whether the BOTMP uses contrived rather than natural movements to test functional balance skills.

The discussion of balance leads us directly into a review of the most common characteristic of Down syndrome, hypotonia. Hypotonia is considered the decreased segmental motor neuron pool excitability and pathology of the stretch reflex mechanism. As previously noted, Shumway-Cook and Woollacott (1985) and other researchers believe that hypotonia may not result in all of the motor difficulties, such as poor balance, that are associated with Down syndrome. However, it is still present in nearly all cases of children with Down syndrome. Crome, Cowie, and Slater (1966) conducted the landmark study on the cerebellar and brain-stem weights associated with Down syndrome. They found a decrease in the total brain weight and a disproportionate decrease in the brain-stem and cerebellar weights taken together (Crome et al., 1966). The weight of the brain was reduced, on average, 76% of the
normal weight and the cerebellum alone was reduced, on average, to less than 66% of the normal weight (Crome et al., 1966). Thus, the hypotonia found with Down syndrome resulted in its being classified as a condition of the central nervous system. Decreased pelvic stability, pes planus, and atlanto-occipital instability are all conditions commonly found with Down's syndrome that are related to the presence of hypotonia. Hypotonicity of the orofacial musculature, in addition to the problems with coordination and motor planning, contribute to the delayed phoneme production in children with Down syndrome (Kumin, Councill, & Goodman, 1994).

Strength has been reported in the past as a common deficit of children with Down syndrome. In the study conducted on children with Down syndrome by Connolly et al. (1984), the gross motor subtest of the BOTMP that was among the top scored subtests was strength. The activities that are used to assess strength on the BOTMP are common activities such as sit-ups, push-ups, and broad jumps. Connolly et al. (1984) proposed the question, "do the scores on the Bruininks Oseretsky test more accurately reflect practice effects rather than true abilities of the children?" (p. 1518). Connolly and Michael (1986) also found that children with Down syndrome performed significantly lower than those without Down syndrome on the strength portion of the BOTMP. However, they noted that both groups, "performed at greater than one-half the strength of their nonretarded peers" (Connolly & Michael, 1986, p. 347).

There is an enormous amount of research on how motor development and proficiency relates to one's intellectual level of IQ. In an attempt to provide a basic
review of this topic, the focus will begin with Groden (1969). He carried out a study to investigate the relationship between specific motor and perceptual motor behaviors and the level of intellectual functioning, or IQ. It was possible to glean from his work that even when certain motor disabilities were controlled, the data results indicated a substantial relationship between motor skill proficiency and IQ. These results also signified that if they do not have any overt motor disability then a child may still demonstrate some deficits in performing complex motor skill tasks based on a relationship to their IQ level (Groden, 1969; Connolly & Michael, 1986). Henderson, Morris, and Ray (1981) looked at chronological age (CA) and mental age (MA) while doing their study on children with Down syndrome and their performance on the Cratty Gross-Motor Test. Both CA and MA were highly correlated with the performance of the children with Down syndrome. The researchers' explanation for these results included that if these children are less physically able than their peers, then they may compensate for their disability in other ways. Those having higher IQ were better able to develop strategies that would aid them (Henderson, Morris, & Ray, 1981). Evidence for delayed development in children with Down syndrome was found in the correlation between CA and performance (Henderson, Morris, & Ray, 1981).

It has been noted that children with Down syndrome demonstrated a decline in their IQ as they age. Melyn and White (1973) regarded this decline, "as an entirely expected psychological phenomenon reflecting the increasing verbal and abstract content of test material at higher mental ages" (p. 545). One must be cautioned to not consider IQ to be the only indication of performance with Down syndrome. There are
many other areas to be considered, such as family life and early intervention, that can affect motor performance. This comment was supported by the findings of Clausen's (1968) study which investigated the characteristics of Down syndrome. When subjects were matched for age and IQ and given The Ability Structure Project battery of tests, significant differences were still found between children with Down syndrome and those with mental retardation (Clausen, 1968). He found, "the Down syndrome subjects seemed to be more impaired with regard to sensory acuity and to some aspects of perceptual speed" (Clausen, 1968, p.124). Connolly, Morgan, Russell, and Fulliton (1993) noted that in their research prior to their study on Down syndrome and early intervention programming, that children who had early intervention programming, "had higher scores on measures of intellectual and adaptive functioning than did children of comparable ages with Down syndrome who did not participate in an early intervention program" (p. 171). The results of their study supported this finding. The IQ of the children that received early intervention programming was significantly higher than the comparison group. Their adaptive skills were also maintained at a higher level and were less affected by the increase in age than the group that did not receive the same early intervention programming (Connolly, Morgan, Russell, & Fulliton, 1993). This research was longitudinal in nature and had a consistent outcome with each follow-up study (Connolly, Morgan, & Russell, 1984; Connolly, Morgan, Russell, & Fulliton, 1993).
Conclusion

Many of the research articles that were reviewed for this study contained implications for the need for further research in the area of testing and treating children with Down syndrome. Connolly and Michael (1986) pointed out that children with Down syndrome have difficulty in the running speed, balance, strength, and visual motor skill areas of the BOTMP. They remarked on how these children would need physical therapy intervention beyond their preschool years and into adolescence, because it is not currently a major factor in their education and overall treatment. Their study demonstrated the differences between children with Down syndrome and those that are mentally retarded.

These differences provided evidence of the need for special programming for children with Down syndrome that is geared at improving their coordination and balance (Connolly & Michael, 1986). "Therefore, the child with Down syndrome may continue to need individualized physical therapy as a part of his special education programming to address his particular motor skill needs" (Connolly & Michael, 1986, p.347). Thus, the researchers of this study can see the need to have a special tool that can validly and effectively assess and evaluate the motor development of children with Down syndrome in order to meet some of the special needs Connolly and Michael brought to our attention.

The BOTMP can fulfill this need. However, without more data on how children with Down syndrome normally perform on the BOTMP, taking into consideration the size of their cerebellum, the hypotonia, and the decreased reaction time, the test has
not been utilized to its fullest potential. In addition, as reported by Miles et al. (1988),
the BOTMP was one of the most commonly used assessment tools by physical
therapists and those teaching adapted physical education, further supporting the need
for more normative data. "Thus a need exists for the development of normative data
for other disability groups served by the adapted physical educator" (Miles et al., 1988,
p.35).

In their study on the performance of children with Down syndrome on the
Cratty Gross-Motor Test, Henderson, Morris, and Ray (1981) noted that, "in spite of
the volumes of studies in which attention had been focused on motor behavior of
retarded persons, there remains an acknowledged lack of well-standardized tests of
referenced the need for physical therapy involvement for children with Down
syndrome in their study on the effects of early intervention programming,
"participation in an organized physical education program even during the adolescent
years may be important in order for the children to continue to make optimal progress
in their gross motor skill development" (p. 178). It was often noted in the older
research that there was a need to further investigate how children with Down
syndrome compared to children with mental retardation on the BOTMP (Connolly,
Morgan, & Russell, 1984; Connolly & Michael, 1986).
The researchers of this study believe that the current research is sufficient in noting that there is a definite difference in motor performance children with Down syndrome and children with mental retardation. Further research is still needed on a larger sample group to determine the degree of this difference (Connolly & Michael, 1986).
CHAPTER 3

METHODOLOGY

This research project was a descriptive normative study. Under this type of research design, the researchers collected normative data on children with Down syndrome between the ages of 4.5-14.5 years. This research would begin to establish standards of performance for this group of individuals based on the BOTMP-SF (Appendix A).

Sampling

A non-probability purposive sampling was used so that we could select subjects that satisfied our predetermined criteria. This type of sampling was necessary due to a very limited population and time constraints for completion of the project. Limitations of this type of sampling included a decrease in: (1) generalizability to the entire Down syndrome population and (2) internal validity of the study. In the future, a comprehensive standardized format, including extensive random sampling, would be necessary to generate normative data which could be generalized to the whole Down syndrome population with greater validity.

The sample of convenience included both boys and girls between the ages of 4 years 11 months and 13 years 7 months. The subjects were volunteers from various schools and support groups throughout Grand Rapids, Holland, and Muskegon, Michigan. The participants were required to have an intelligence level of no lower than trainable mentally impaired; (IQ > 34). Because of the characteristic morphology of Down syndrome, the researchers did not want to exclude participants based upon
the common signs and symptoms of the condition. The researchers felt that this information would be very valuable in establishing norms, since that is how these children present clinically. Therefore, exclusionary criteria was based on safety issues and other conditions, not characteristic of Down syndrome, that might affect the results of the tests. These conditions included: 1) uncontrolled cardiopulmonary conditions, such as blood pressure, angina, or asthma 2) orthopedic problems that are limiting or that would be exacerbated by the tests 3) an intelligence level below trainable mentally impaired 4) severe neurological disorders, such as epilepsy or cerebral palsy.

Instrumentation

The instrumentation that was used for evaluating motor proficiency was the BOTMP-SF. All tools and materials were standardized by the BOTMP test kit. The BOTMP test kit included the examiner's manual, individual record forms, a student booklet, and equipment needed for testing. The BOTMP-SF was comprised of 14 items from the complete battery which provided a brief survey of general motor proficiency (Bruininks, 1978). For specific validity and reliability issues of the BOTMP-SF see literature review page 9.

Procedures

Approval for using the BOTMP-SF was granted from The American Guidance Service, Circle Pines, MN (Appendix B). Testing using the BOTMP-SF was conducted by three physical therapy masters students from Grand Valley State University.
The examiners were not required to have special training to administer this test. However, all three examiners became thoroughly familiar with the directions and procedures prior to administration by reading through the examiner’s manual and practicing the test on children without Down syndrome. To help maintain internal validity, the researchers followed the guidelines for test administration set forth by the examiner’s manual (Bruininks, 1978, p. 44). During the late summer of 1996, the researchers traveled to the program sites, schools, and homes to administer the tests either outside on grass or in a gymnasium. Each volunteer, with parent or legal guardian, was informed of the purpose and procedures of the study. Then they were asked to fill out a consent form (Appendix C), and medical history form (Appendix D) prior to participation. An information sheet (Appendix E) was distributed at test sites. The environment was controlled for excessive distractions, spectators, and stress. Adequate space, lighting and ventilation were considered when choosing the test setting.

A pretest was given to each volunteer to determine arm and leg preference. Use of the preferred limb was required for some tests. The BOTMP-SF was given to each volunteer on an individual basis to decrease performance anxiety and distractions. The complete test took approximately 20-30 minutes. The participant had the right to stop the test at any time for any reason if he/she chose. The results were recorded as a raw score for each test. An area for notes and observations was available if necessary. These raw scores were converted into point scores so that they would be comparable to the standardized norms previously established. Data collected was encoded to
protect the identity of the participants. After data analysis any information containing
a name or any other identifying information was destroyed to insure confidentiality.

Data Analysis and Limitations

Analysis of the collected data was of a descriptive nature. Of the subjects tested
there were 15 boys with a mean age 9.26 of and 5 girls with a mean age of 9.36
(n=20). The researchers ran summary statistics on the normative values collected.
Histograms were used when appropriate. The significance level was set at p=0.05
signifying a 95% confidence level. Once the data was collected, other statistical
measures, such as Mann-Whitney U Rank Sum Test, were employed to look into the
relationships between the ages or conditions of the children who participated in the
study.

Limitations of the study included the following; sampling method, the small
sample size, access to the Down syndrome population, geographic restrictions, lack of
cultural diversity, limited time in which to conduct the research, and temporal aspects
of the Bruininks norms. Normative data was collected by Dr. Bruininks in 1973. Since
that time, there has been a big social campaign for physical fitness and health which
may alter the norms if they were to be tested again today. The potential lack of validity
and inter-rater reliability measures throughout all eight subtests may also be a
limitation of this study.
CHAPTER 4
DATA ANALYSIS AND RESULTS

The original hypothesis of this study was that children with Down syndrome, who are educable and trainable mentally impaired, will perform lower than the established normative values as indicated in the BOTMP examiner's manual. Data was analyzed by computer using the Statistical Analysis System (SAS). The scores of 15 boys and 5 girls were compiled and summarized by all three researchers. The test score summary portion on the front of the BOTMP-SF was completed and all calculations were double checked by the researchers.

Results of Data Collection

The demographic presentation of the subjects and their performance on the BOTMP-SF will be presented in a series of Tables numbered 1 through 4 can be found in Appendix E. The results of the data collection for the total point score, standard score, percentile rank, and stanine are included in Table 1. The total point scores ranged from zero to 43 with a mean score of 15.5 and standard deviation of 13.0. Individual performance of each of the eight subtests is presented in Table 2. The eight subtests, in order as they appear in the table are as follows; (1) running speed and agility, (2) balance, (3) bilateral coordination, (4) strength, (5) response speed, (6) visual motor control, (7) upper limb speed and dexterity, (8) and upper limb coordination.
Performance on these individual subtests increased with chronological age. The response to the medical questionnaire (Appendix D) can be seen in Table 3. The most commonly seen deficits were heart conditions, hearing deficits, allergies, and visual deficits. Finally, the division of females versus males and their level of mental retardation can be seen in Table 4. The arm preference on the BOTMP-SF by these subjects was 80% right and 20% left. The leg preference was 80% right, 15% left, and 5% mixed.

Data Analysis

Descriptive statistical analysis was used to examine the mean and standard deviation of the data. The total point score, which is the sum of the total points of all of the eight subtests, presented with a mean of 15.5 and standard deviation of 13.0 in the 20 subjects in this study. The mean age of the subjects was 9.29 or nine years and 2 months with a standard deviation of 3.42 years. The mean score and standard deviations for the eight subtests are included in Table 5. Subtests 1, 4, 6, and 7 had standard deviations greater than the mean. This could be attributed to the very low performance on these subtests and the relatively small sample size.

Table 5

Mean Score and Standard Deviations for the Eight Subtests

<table>
<thead>
<tr>
<th>Subtest</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.80</td>
<td>2.44</td>
</tr>
<tr>
<td>2</td>
<td>1.40</td>
<td>.99</td>
</tr>
<tr>
<td>3</td>
<td>1.30</td>
<td>1.08</td>
</tr>
<tr>
<td>4</td>
<td>2.80</td>
<td>3.30</td>
</tr>
<tr>
<td>5</td>
<td>2.65</td>
<td>2.60</td>
</tr>
<tr>
<td>6</td>
<td>.70</td>
<td>1.72</td>
</tr>
<tr>
<td>7</td>
<td>1.75</td>
<td>2.27</td>
</tr>
<tr>
<td>8</td>
<td>3.15</td>
<td>2.91</td>
</tr>
</tbody>
</table>
The percentages of the subjects within the study with health related issues derived from the medical questionnaire (Appendix D) can be seen in Table 6. Only those health problems that were frequently present in the subjects are represented in this table.

Table 6

Percentages of the Subjects With and Without Health Conditions

<table>
<thead>
<tr>
<th>Health Condition</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart condition</td>
<td>65.0%</td>
<td>35.0%</td>
</tr>
<tr>
<td>Persistent cough</td>
<td>15.0%</td>
<td>85.0%</td>
</tr>
<tr>
<td>Asthma</td>
<td>20.0%</td>
<td>80.0%</td>
</tr>
<tr>
<td>Allergies</td>
<td>30.0%</td>
<td>70.0%</td>
</tr>
<tr>
<td>Hearing Deficits</td>
<td>65.0%</td>
<td>35.0%</td>
</tr>
<tr>
<td>Visual Deficits</td>
<td>45.0%</td>
<td>55.0%</td>
</tr>
<tr>
<td>Orthopedic Problems</td>
<td>15.0%</td>
<td>85.0%</td>
</tr>
</tbody>
</table>

A histogram illustrating the comparison between total score and age (Graph 1) showed a linear increase in the total score with the subsequent increase in age. These results coincide with the performance of children without Down syndrome on the BOTMP-SF (Bruininks, 1978; Connolly & Michael, 1984).

Graph 1
The comparison of the total score of the children with Down syndrome with those who did not have Down syndrome when matched for age and sex showed a significant difference between their respective scores. In fact, ninety-nine percent of the children without Down syndrome, when matched for age and sex, performed higher than the children with Down syndrome. These results confirm the hypothesis of this study and provide rationale for the development of normative values for the population of children with Down syndrome.

The use of the Mann-Whitney U Rank Sum test showed that the mean scores for children with Down syndrome who had a heart condition were not significantly different from the mean scores for children with Down syndrome who had no heart condition (p-value < 0.05). This result came as a surprise to the researchers who believed that the subjects with a heart condition would have a lower total score than those subjects who did not have a heart condition. The actual mean rank of the total score for the children with and without a heart condition was 9.32 and 12.71 respectively. However, despite the mean rank total score being lower in those with heart conditions, the difference was not statistically significant with an alpha level of 0.05.

The Mann-Whitney Test was also used to examine the total scores of the subjects who did and did not have the following additional medical conditions: (1) persistent cough, (2) asthma, (3) allergies, (4) hearing impairments, (5) visual deficits, (6) vestibular deficits, and (7) orthopedic problems. The result of these tests can been seen in Table 7 which illustrates the number of subjects with and without each medical condition, the mean rank of their total score, and whether or not there was a statistical difference between the two groups. At the p-value of 0.05, the researchers can assume with 95% confidence that there will be no statistically significant differences between the subjects who do and those who do not have the listed medical conditions.
Table 7
Results of Mann-Whitney U Rank Sum Test for the Effects of Medical Conditions on the Total Score with the BOTMP-SF (p-value < 0.05).

<table>
<thead>
<tr>
<th>Health condition</th>
<th>Mean total score With the condition</th>
<th>Mean total score Without the condition</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart condition</td>
<td>9.31 (13)</td>
<td>12.71 (7)</td>
<td>.2171</td>
</tr>
<tr>
<td>Persistent cough</td>
<td>13.83 (3)</td>
<td>9.91 (17)</td>
<td>.2875</td>
</tr>
<tr>
<td>Asthma</td>
<td>9.50 (4)</td>
<td>10.75 (16)</td>
<td>.7041</td>
</tr>
<tr>
<td>Allergies</td>
<td>12.83 (6)</td>
<td>9.50 (14)</td>
<td>.2459</td>
</tr>
<tr>
<td>Hearing Deficit</td>
<td>10.69 (13)</td>
<td>10.14 (7)</td>
<td>.8422</td>
</tr>
<tr>
<td>Visual Deficit</td>
<td>11.89 (9)</td>
<td>9.36 (11)</td>
<td>.3399</td>
</tr>
<tr>
<td>Orthopedic Deficit</td>
<td>11.00 (3)</td>
<td>10.41 (17)</td>
<td>.8732</td>
</tr>
</tbody>
</table>

The Mann-Whitney Test was also used to examine the effects of past hospitalization and past physical therapy treatment on the performance of the subjects. Of those subjects who had been hospitalized in the past, 14 total, and those who had not, 6 total, the mean rank total score on the BOTMP-SF was 10.39 and 10.75, respectively. These results demonstrate that there is no significant difference (p-value < 0.05) in performance on the BOTMP-SF between those subjects who have been hospitalized in the past and those who had not.

Similarly, the effects of past physical therapy treatment on the performance of the BOTMP-SF were examined. Again using the Mann-Whitney Test, the comparison of those subjects who had received previous therapy treatment at any point in their lives, 12 total, and those who had not received past physical therapy, 8 total, resulted in mean rank total scores of 9.67 and 11.75, respectively. These results indicate no significant difference (p-value < 0.05) in the performance of those subjects with and without previous physical therapy intervention.
A comparison on the total scores of the males versus females was completed using the Mann-Whitney Test. There was no statistically significant difference (p-value < 0.05) between the performance of the males and females on the BOTMP-SF. The low number of subjects in this study could affect the accuracy of this comparison.

Finally, the Mann-Whitney Test was used to examine the differences between the subjects when categorized by their level of mental impairment. The pre-established levels of mental impairment were used and are as follows: (1) average with IQ above 70, (2) educable mentally impaired with IQ 70-50, (3) trainable mentally impaired with IQ 49-35, (4) severely mentally impaired with IQ 34-20, and (5) profoundly mentally impaired with IQ 20 or below. This study used subjects who were in the first three categories. There was one subject who was not impaired, and one subject for whom the level of impairment was unknown. These two subjects were excluded from this comparison. The remainder of the subjects were educable mentally impaired (5) and trainable mentally impaired (13). The subjects who were educable mentally impaired performed significantly higher when analyzing the total score on the BOTMP-SF, p-value = 0.0263, than those subjects who were trainable mentally impaired.
CHAPTER 5
DISCUSSION AND IMPLICATIONS

Results

The results of the data collection for this study strongly supported the researcher’s hypothesis that children with Down syndrome, who are educable and trainable mentally impaired, will perform lower than the established normative values as indicated in the BOTMP examiner’s manual. It is important to note that this study used a sample of convenience and generalizations cannot be made to the entire population of children with Down syndrome. Ninety-nine percent of children without Down syndrome, when matched for age and sex, would perform higher than the children with Down syndrome. A quantitative value for how much lower this population scored when compared to the normative values was not made for reasons to be stated in the discussion on limitations of this study. The results of this study indicate that the BOTMP is not the best choice of evaluation tools when studying children with Down syndrome, unless further normative studies on this special population can be completed. The following discussion will review how the symptoms of Down syndrome affected the results of this study.

The results followed an upward linear progression of motor skills for children with Down syndrome when plotted for age. This suggests that as children with Down syndrome age, their performance on the BOTMP will increase. The IQ level of the children was the only factor that had significance with an alpha level of 0.05. Those
subjects who were educable mentally impaired performed significantly higher on the
BOTMP-SF than those who were trainable mentally impaired. These findings support a
study by Groeden (1969) which indicated a substantial relationship between motor skill
proficiency and IQ. Henderson, Morris, and Ray (1981) noted that those with higher IQ’s
were better able to develop strategies that would aid them in their motor performance.
The researchers suggest that if normative data is ever collected for this population it
should be established for each level of mental impairment. The research of Connolly and
Michael (1986) also paralleled the findings of our study with relationship between higher
IQ’s and better motor performance.

The results of this study showed no statistically significant difference between
males and females on their performance on the BOTMP-SF. These findings support those
of Connolly and Michael (1986) in their study of similar design. Studies by LaVeck and
LaVeck (1977), Melyn and White (1973), and Connolly, Morgan, and Russell (1984)
showed a difference in the motor development and performance of skills between the
sexes. It was shown that females perform better on the BOTMP in one of these studies;
however, more current research, including this study, refutes this.

The results of subtest 1, running speed and agility, could have been attributed to a
number of factors related to Down syndrome. First, Henderson, Morris, and Frith (1981)
noted that children with Down syndrome would have more difficulty motor planning than
children who did not have Down syndrome who were mentally retarded when a task had
timed elements. This proved to be the case with this subtest which was timed and the
subjects knew they had to run as quickly as they could. Our results also related to those
of Henderson, Morris, and Ray (1981) that children with Down syndrome performed a task more slowly, especially when a speed criterion was imposed. The condition of hypotonia that is the single most common characteristic of Down syndrome can also be considered a factor in the poor performance on this subtest 1. In addition to deficits in strength and reaction time, slowed performance scores on this test could also be related to the decreased pelvic stability and pes planus conditions that are commonly the result of hypotonia in children with Down syndrome (Connolly, Morgan, and Russell, 1984).

Subtest 2 tested balance skills. The subjects had an extremely difficult time performing this test. The findings of this study were similar to those of Henderson, Morris, and Ray (1981) and Connolly and Michael (1986) which illustrated a decrease in the performance of children with Down syndrome on balance related tasks. The decrease in cerebellar size and hypotonia in children with Down syndrome are said to be the causal factors in their balance deficits (Frith & Frith, 1974). In addition, a deficit in the feedforward motor programming that is required for balance reactions could also be attributed for their poor performance (Henderson, Morris, & Frith, 1981). Another related area that could be related to the balance deficits is the abnormalities within the automatic postural control system that were noted by Shumway-Cook and Woollacott (1985). Reaction time and hypotonia, as mentioned during the discussion of subtest 1, could also explain the balance deficits found in the subjects of this study.

The results of subtest 3, bilateral coordination, were also found to be extremely low when compared with the normative values. These results are representative of the many studies that have shown deficits in eye-hand coordination and visual motor control

The subtest measuring strength, Subtest 4, was among the top scored subtest of these subjects. These results mimic those of Connolly et al (1984) when they performed the BOTMP on children with Down syndrome. The activity was a standing broad jump which most of the children had performed before. The issue of practice and its carry over into the results of this portion of the test is one many researchers have concern with because it may abnormally increase their performance (Connolly et al., 1984). However, the practice effect may be incorporated into the normative data due to similar activities in children without Down syndrome.

Subtest 5, response speed, was perhaps the most difficult for these subjects to perform. Comprehension and distractibility played a major role in their lack of success. The major reason for the deficits in this area by these subjects can be attributed to the characteristic slowness of reaction time in children with Down syndrome (Berkson, 1960; Hermelin & Venables, 1964; Henderson, Morris, & Frith, 1981). This subtest required quick movements by the subjects in addition to demanding hand-eye coordination. Frith and Frith (1974) reported that children with Down syndrome, “should do relatively well in motor tasks requiring slow movements following no predetermined course but relatively badly at tasks involving fast and regular movements” (p. 299).

The remaining subtests, 6, 7, and 8, tested visual-motor control, upper-limb speed and dexterity, and upper-limb coordination, respectively. The tasks that were involved with these subtests were drawing a straight line through a path, a timed card sorting task,
and copying shapes such as a circle. All of these tasks required visual motor skill control. As with Subtest 1, because a temporal constraint was placed on some of these tasks, it made it more difficult for the subjects (Henderson, Morris, & Frith, 1981; Henderson, Morris, & Ray, 1981). As stated previously, the research to support the deficits in eye-hand coordination and visual motor control in children with Down syndrome is overwhelming (Clausen, 1968; Frith & Frith, 1974; Seyfort & Spreen, 1979; Henderson, Morris, & Frith, 1981; Henderson, Morris, & Ray, 1981). The researchers of this study attribute the deficits in these subtests to the slow reaction time and visual motor control problems in children with Down syndrome. In addition to the above mentioned research studies, our study also supports the findings of Davis and Kelso (1982) that the children with Down syndrome were, “less accurate in controlling movements than their age equivalent peers” (p. 209).

The percentages of our subjects that had heart conditions and visual and hearing deficits were high and expected for this population. Surprisingly, none of these conditions had a statistically significant effect on the subject’s performance when compared to those without the condition. Our relatively small sample size could explain this lack of significance.

Similarly, an analysis on the effects of previous hospitalization and previous physical therapy treatment showed no significant effect on the performance of the subjects in this study. Again, our relatively small sample size could explain this lack of significance.
Limitations and Strengths

The raw score from each individual test was converted into a point score, then all subtest point scores were added to determine the total point score for that child. The total point score was then converted to a percentile value using a normative table from the BOTMP examiner's manual. The percentile values are used to rank motor proficiency skills of the children within their age group. The researchers found that percentile values were not useful in evaluation of children with Down syndrome. All but one child tested was not able to score high enough to hit the baseline of the percentile table. The researchers were unable to differentiate the children's motor skills based on the percentile value; therefore, the total point score was used for data analysis. Using the total point score was not ideal because in the conversion of the raw score to the point score many of the values were zero, contributing to a lower total point score. The researchers suggest that the raw score should be used in the future when comparing children with Down syndrome.

According to the examiner's manual, specific instructions were to be given before each subtest to maintain reliability. The researchers found this control difficult to follow. The Down syndrome population required a large amount of modeling and repetition of the instructions for comprehension. Verbal encouragement throughout the test was also necessary to keep the child on task secondary to attention deficits.

Limitations existed within the study and the BOTMP-SF. Limitations of the sample included a small sample of convenience, a greater ratio of males to females, and volunteers from similar geographical areas. There was also a lack of same-age subjects
to be able to make comparisons within an age group, and the researchers did not control for extracurricular activities which could enhance performance. There were limitations in the testing procedure. The location of testing was variable. Locations included in-home, outdoors on grass, outdoors on pavement, and in a gymnasium. The testing environment was difficult to control due to family interaction and location. The researchers suggest stricter testing conditions should be used when testing children with Down syndrome whom are distractible.

A limitation of the BOTMP-SF was that the scoring system was not sensitive enough to detect changes at the low end of the scale. Because the BOTMP was not designed for children with Down syndrome, tests like the balance beam test did not take into consideration the balance deficits of this population as noted previously. The researchers agree with DePaepe and Ciccarelione (1993) that the BOTMP may contain contrived rather than natural movements to test functional balance skills. Specific deficits related to the characteristics of Down syndrome were not considered during the formation of the BOTMP. Therefore, the need of normative data and/or a test specifically designed for this population is warranted.

The researchers believe that, although not great in number, the amount of subjects used for this study was adequate considering the time constraints and scope of the requirements made upon them. In addition, this population is somewhat specialized and limited, thus complicating this issue.

The results strongly supported the hypothesis of this study and provided strong implications for further research. The results demonstrated how the characteristics of
Down syndrome could affect motor performance. In fact, the results were strongly supported by the literature reviewed for this study regarding these characteristics.

Implications

Clinically, if children with Down syndrome are being tested on the BOTMP-SF and compared with the norms established in the examiner’s manual, then their progress will not be evident. If the BOTMP-SF is to be used clinically, then children with Down syndrome should be evaluated on their raw score and only compared to themselves until normative data on this population can be established. Future research is needed to establish normative data for children with Down syndrome. Research should focus on development of a more sensitive evaluation tool that could detect incremental advancement of motor skills in children with Down syndrome.

The overall performance of the subjects in this study was poor when compared to the normative values on the BOTMP. It has been shown throughout the review of the literature and the results of this study that children with Down syndrome have many unique conditions that can strongly affect their motor performance. Although the subjects performance improved with age, it can be suggested that these children will continue to have problems into and beyond adolescence. Connolly and Michael (1986) note that, “currently, the majority of physical therapy available to the child with Down syndrome is provided during the pre-school years and not after the child enters a regular school program” (p. 347). Our study supports that children with Down syndrome may continue to require individualized physical therapy treatment and/or adaptive physical
education to address their motor skill needs all through development, including adolescence.

Recommendation for Further Study

There is currently not a test that takes into consideration areas such as the size of the cerebellum, the hypotonia, the decreased reaction time, and the decreased balance found in children with Down syndrome. It has been clearly stated throughout this discussion that this study proved the need for the establishment of normative data on the performance of children with Down syndrome on the BOTMP. The researchers were able to conclude upon completion of this study that perhaps the BOTMP is not a sensitive enough test for this population because it is not geared toward their specific condition characteristics. The establishment of normative data for this population may not be possible secondary to the varying degree of deficits found in children with Down syndrome. Therefore, we would recommend a test be devised specifically for the measurement of gross and fine motor performance in children with Down syndrome. Henderson, Morris, and Ray (1981) noted that, “there remains an acknowledged lack of well-standardized tests of motor performance” (p. 416).

Conclusion

To conclude, the BOTMP-SF is a useful tool in evaluating motor proficiency in the general population. However, it is not as useful in evaluation special populations such as children with Down syndrome. Because of the characteristics of Down syndrome modifications will need to be made if the BOTMP-SF is to be used clinically. The Down syndrome population is frequently seen in the clinic and therefore need an effective
evaluation tool to objectively measure progress and functional outcomes. The researchers believe that this study was important in establishing a need for normative data to be collected on this specialized population and new tests to be created to assist physical therapists and other professionals with the objective evaluation and treatment children with Down syndrome.
REFERENCES


## APPENDIX A

### BRUININKS OSERETSKY TEST OF MOTOR PROFICIENCY

#### SHORT FORM

**Name:**

**School/Agency:**

**Examiner:**

**Purpose of Testing:**

**Age:**

**Test Score Summary**

<table>
<thead>
<tr>
<th>Test Score Item</th>
<th>Short Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed and Agility</td>
<td>98</td>
</tr>
<tr>
<td>Balance</td>
<td></td>
</tr>
<tr>
<td>Bilateral Coordination</td>
<td></td>
</tr>
<tr>
<td>Strength</td>
<td></td>
</tr>
<tr>
<td>Upper-Limb Coordination</td>
<td></td>
</tr>
</tbody>
</table>

**Directions:**

1. During test administration, record subject’s response for each trial.

2. After test administration, convert performance on each item (item raw score) to a point score, using scale provided. For an item with more than one trial, choose best performance. Record item point score in square to right of scale.

**Notes/Observations**

---

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### SUBTEST 6: Response Speed

1. **Response Speed**

<table>
<thead>
<tr>
<th>Trial</th>
<th>Time (Sec)</th>
<th>Score</th>
</tr>
</thead>
<tbody>
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<td>3</td>
<td>DDK</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>DDK</td>
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<tr>
<td>3</td>
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<td>DDK</td>
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<td>DDK</td>
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<tr>
<td>10</td>
<td>12</td>
<td>DDK</td>
</tr>
</tbody>
</table>

**Instructions:**
- Time limit: 0 seconds maximum per trial.
- Score: DDK (Disqualified due to excessive errors).

### SUBTEST 7: Visual-Motor Control

3. **Drawing a Line Through a Straight Path with Preferred Hand**

<table>
<thead>
<tr>
<th>Errors</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td>DDK</td>
</tr>
<tr>
<td>2</td>
<td>DDK</td>
</tr>
</tbody>
</table>

4. **Copying a Circle with Preferred Hand**

<table>
<thead>
<tr>
<th>Errors</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>DDK</td>
</tr>
<tr>
<td>1</td>
<td>DDK</td>
</tr>
</tbody>
</table>

5. **Copying Overlapping Circles with Preferred Hand**

<table>
<thead>
<tr>
<th>Errors</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>DDK</td>
</tr>
<tr>
<td>1</td>
<td>DDK</td>
</tr>
</tbody>
</table>

### SUBTEST 8: Upper-Limb Speed and Dexterity

3. **Sorting Shape Cards with Preferred Hand**

<table>
<thead>
<tr>
<th>Cards</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DDK</td>
</tr>
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<td>DDK</td>
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<tr>
<td>4</td>
<td>DDK</td>
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<tr>
<td>5</td>
<td>DDK</td>
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<tr>
<td>6</td>
<td>DDK</td>
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<tr>
<td>7</td>
<td>DDK</td>
</tr>
<tr>
<td>8</td>
<td>DDK</td>
</tr>
<tr>
<td>9</td>
<td>DDK</td>
</tr>
</tbody>
</table>

6. **Making Dots in Circles with Preferred Hand**

<table>
<thead>
<tr>
<th>Dots</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DDK</td>
</tr>
<tr>
<td>2</td>
<td>DDK</td>
</tr>
<tr>
<td>3</td>
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<td>DDK</td>
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<tr>
<td>5</td>
<td>DDK</td>
</tr>
<tr>
<td>6</td>
<td>DDK</td>
</tr>
</tbody>
</table>

**Notes:**
- For items 5 and 6 in SUBTEST 7, use scoring criteria in Appendix A of Examiner's Manual.
August 5, 1996

Kristine Tyler
1756 Sunset Point
Muskegon, MI 49441

Dear Ms. Tyler:

AGS grants you permission to use the Bruininks-Oseretsky Test of Motor Proficiency (BO) for your research study on "How Children with Down Syndrome Perform on the Bruininks-Oseretsky Test."

We would appreciate receiving a copy once you have completed your study. Good luck!

Sincerely,

Mark H. Daniel, Ph.D.
Director
Product Development

MHD/lf
APPENDIX C
CONSENT FORM

I understand as parent or legal guardian that my child will be asked to perform motor activities described by the Bruininks Oseretsky Test-Short Form, (BOT-SF). The BOT-SF is a standardized test made up of eight sub-tests that evaluate running speed and agility, balance, bilateral coordination, strength, upper-limb coordination, response speed, visual-motor control, and upper-limb speed and dexterity. The results of this study will be used to generate normative values for children with Down syndrome between the ages of 4.5-14.5 years.

I understand and acknowledge all of the following statements:

* Emotional or physical risk is not expected in performing the BOT-SF Test. All measures, to the best of the investigator's ability, will be taken to ensure the safety of participants.

* Administration of the eight subtests will take approximately 30-40 mins.

* Participation is on a voluntary basis. Participants may terminate the test at any time upon their request without penalty.

* All data sheets will be encoded to ensure confidentiality.

* The investigators will be available for any questions through the Physical Therapy Department at Grand Valley State University.

* Results of this study will be made available upon written request.

I hereby authorize Erin Docter, Kristine Tyler, and Victoria Van Horn to use the results of these tests for their study and release the findings to the scientific literature.

I am fully aware that confidentiality will be maintained throughout this research project. Documentation containing a volunteer's name will be destroyed after the data collection phase.

I acknowledge that I have read and understand the above information. Permission for my child to participate in this study is granted.

_________________________  ___________  _______________________
Parent or Legal Guardian    Date                  Witness

* please have participant wear tennis shoes on day of testing.

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APPENDIX D
MEDICAL HISTORY QUESTIONNAIRE

Volunteer’s Name: ____________________________
Date of Birth: ____________________________
Phone: ____________________________
Physician: ____________________________
School attending: ____________________________

Have you ever consulted, for your child, with a physician for any of the following conditions? These conditions are important as they may affect the results of the Bruininiks-Oseretsky Test.

Heart conditions:  Y / N
Dizziness/Fainting:  Y / N
Hypertension:  Y / N
Headaches:  Y / N
Seizures:  Y / N
Head Injuries:  Y / N
Hypoglycemia:  Y / N
Diabetes:  Y / N
Persistent Cough:  Y / N
Lung Disease:  Y / N
Asthma:  Y / N
Allergies:  Y / N
Hearing Problems:  Y / N
Visual Problems:  Y / N
Vestibular Problems:  Y / N
Orthopedic Problems:  Y / N
Hospitalization:  -  Y / N
Other Conditions: ____________________________

Please explain any ‘YES’ answers:

Please list all surgical procedures and current medications:

Has your child ever received physical therapy in the past? Currently? If so, how long and was it beneficial?
What is the IQ of your child?  
(If unsure please choose category below).

____ Average  
IQ: above 70

____ Educable mentally impaired (EMI)  
IQ: 70-50

____ Trainable mentally impaired (TMI)  
IQ: 49-35

____ Severely mentally impaired (SMI)  
IQ: 34-20

____ Profoundly mentally impaired (PMI)  
IQ: 20-00

This test is not any more stressful than average daily play activities. However, if the participant is restricted from physical activity by their physician a signed permission statement must accompany this form.

As Parent or Legal Guardian I understand that my child may be excluded from the study based on the results of this questionnaire, as some conditions may impact reliability.

_________________________  _________________________
Parent or Legal Guardian  Date
APPENDIX E
INFORMATION SHEET
Information Sheet for Parents/Guardians and Participants

The purpose of this study is to determine a beginning level of normative data on how children with Down syndrome, ages 4.5 to 14.5 perform on the Bruininks-Oseretsky Test of Motor Proficiency Short Form (BOTMP-SF). The test was developed by Dr. Robert H. Bruininks in 1978, "to provide educators, clinicians, and researchers with useful information to assist them in assessing motor skills of individual students, in developing and evaluating motor training programs, and in assessing serious motor dysfunction and development of handicaps in children" (Bruininks Examiners Manual).

The test consists of eight subtests, four measure gross motor skills, three measure fine motor skills, and one measures a combination of gross and fine motor skills. The activities are listed below. The physical demand of the test on the children is no more strenuous than an active day of play or gym class. In fact the activities are designed to be fun and interesting for the children.

All reasonable measures will be taken to provide a safe and enjoyable experience for your child. In addition, complete confidentiality will be implemented throughout the entire study. All the names will be encoded and all records of the participants involvement will be destroyed upon the completion of the study.

The study is being conducted by three physical therapy graduate students at Grand Valley State University (GVSU). The research committee is made up of two physical therapists, a professor of health science, and a statistician. The chairman of the thesis committee is Barb Baker, MPT. She is a physical therapist with experience in the evaluation and treatment of children. She is also a professor of physical therapy at GVSU.

All research with human subjects at GVSU is reviewed by the Human Subjects Committee. The committee has very strict criteria for safety and ethics when working with human subjects. This study is currently being processed by the Human Subjects Committee. The chairman of the Human Subjects Committee is Paul Hiezenga. Both
Paul Hiezenga (616)895-2472 and Barb Baker (616)895-3356 can be contacted with any questions or concerns regarding your child's participation in the study.

**The Bruininks Test - Short Form Activities**

Running Speed and Agility - Child runs down to a marker and back.

Standing on Preferred Leg and Balance Beam - Child stands on dominant leg on a floor balance beam.

Walking Forward Heel-to-toe on Balance Beam - Child attempts to walk heel-toe on same balance beam.

Tapping Feet Alternately While Making Circles with Fingers Jumping Up and Clapping Hands - Child jumps and tries to clap as many times as possible.

Standing Broad Jump - Child jumps as far as possible from both feet.

Catching a Tossed Ball with Both Hands

Throwing a Ball at a Target with Preferred Hand

Response Speed

Drawing a Line Through a Straight Path with Preferred Hand

Copying a Circle with Preferred Hand

Copying Overlapping Pencils with Preferred Hand

Sorting Shape Cards with Preferred Hand

Making dots in Circles with Preferred Hand

Thank you for your time in reviewing this information. We hope to help make a difference in the treatment and education of children with Down syndrome by providing important normative data on a test that can aid educators and health care professionals.

Erin Docter SPT          Kristine Tyler SPT          Victoria Van Horn SPT
APPENDIX F

DATA RESULTS IN TABLE FORMAT

Table 1

Results of Total Point Score, Standard Score, Percentile Rank, and Stanine on the BOTMP-SF

<table>
<thead>
<tr>
<th>Subject</th>
<th>Total point score</th>
<th>Standard score</th>
<th>Percentile rank</th>
<th>Stanine</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>40</td>
<td>24-</td>
<td>1-</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>19</td>
<td>24-</td>
<td>1-</td>
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</tr>
<tr>
<td>C</td>
<td>9</td>
<td>24-</td>
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Responses of the Subjects to the Medical Questionnaire

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Subjects Sex and Level of Mental Impairment

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