Administration of the Bruininks-Oseretsky Test of Motor Proficiency to Healthy 25 to 30 Year Old Males

M. Michelle Butler  
*Grand Valley State University*

Vanessa L. Koschtial  
*Grand Valley State University*

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ADMINISTRATION OF THE BRUININKS-OSERETSKY
TEST OF MOTOR PROFICIENCY TO HEALTHY
25 TO 30 YEAR OLD MALES

by

M. Michelle Butler and
Vanessa L. Koschtial

THESIS

Submitted to the Department of Physical Therapy
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ABSTRACT

ADMINISTRATION OF THE BRUIINKS-OSERETSKY TEST OF MOTOR PROFICIENCY TO HEALTHY 25 TO 30 YEAR OLD MALES

by

M. Michelle Butler and Vanessa L. Koschtial

The purpose of this study was to investigate the standards of performance on the Bruininks-Oseretsky Test of Motor Proficiency-Short Form (BOT-S) of healthy males from 25 to 30 years of age. Although the BOT-S was developed and standardized on children, this test is used by physical therapists to assess adult patients with traumatic brain injuries (TBIs). The BOT-S evaluates both gross and fine motor control. Reliability and validity of the BOT-S have been established on children 4.5 to 14.5 years of age. This study estimated standard scores for 25 to 30 year old males on the BOT-S.

This study was descriptive in design. The BOT-S was administered to 35 healthy 25 to 30 year old males. A statistically significant difference to the p<.001 value was found in the standard scores between 14.5 year old children and the adult male sample. Ceiling effects occurred in test item design and in scoring technique.

A need for adult normative values was established in this study. Such values would increase the clinical usefulness of the BOT-S with adult patients.
DEDICATION

These researchers would like to dedicate this work to our families, Lance and Lori Koschtial, and Lawrence T. Stanley. Their love, support, and guidance encouraged us throughout our academic career.
ACKNOWLEDGEMENTS

The investigators would like to acknowledge the following individuals for time, assistance, and guidance of the following individuals: Cathy Harro, P.T., Garry Mattox, O.T.R., James Scott, Powerhouse Gyms, Steelcase Industries, Dr. R.H. Bruininks, and Austin Financial Services. The investigators wish to extend special thanks to Barbara Baker, M.P.T., committee chair, whose many long hours of guidance and moral support of this study made it a successful learning experience.
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CHAPTER 1
INTRODUCTION

Since 1978 the Bruininks-Oseretsky Test of Motor Proficiency (BOT) has been a valid and reliable measure of motor performance in children (Bruininks, 1978). Dr. Bruininks established age-related normative values from an extensive standardization program for children 4.5 to 14.5 years of age. Over the years, the BOT has also been utilized by physicians, physical therapists and occupational therapists as a clinical assessment tool for adult patients with traumatic brain injuries (personal interviews, Appendix A). Our study will estimate normative values on the BOT Short Form (BOT-S) using males from 25 to 30 years of age. This age range of males statistically has a high incidence of TBIs (Umphred, 1990 and McCance & Huether, 1990). Therefore, normative data would be helpful for physical therapists testing these patients.

Introductory Paragraphs

Dr. Robert H. Bruininks began developing the BOT in 1972 as a revision of the Oseretsky Tests (Bruininks, 1978). The Oseretsky Tests measured the neurological development of
children. Through research and a series of analytical studies, Dr. Bruininks began adapting the Oseretsky Tests by identifying distinct indicators of gross and fine motor skills. The relationship between the significant indicators identified by Dr. Bruininks and indicators identified by other investigators is shown in Figure 1.

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Figure 1: Relationship of the BOT content to aspects of motor development identified by various investigators. Taken from the BOT manual, p 29 (Bruininks, 1978).

These indicators were used to help guide test construction. The final version was constructed after two field tests involving 325 children (Connolly, 1987). Test content consists of 18 items from the original Oseretsky Tests and 28 new items (Connolly, 1987). Standardization of the final version was performed on 756 children between 4.5 and 14.5 years of age.
The BOT assesses the motor skills of children and adolescents through a series of eight subtests containing 46 test items. The purpose of the test is to assist clinicians and educators with placement decisions for special programs, developing therapeutic training programs, early identification of neurological problems, and research. Each subtest was designed to measure a distinct aspect of motor performance. The specific areas of motor performance assessed by the subtests are running speed and agility, balance, bilateral coordination, strength, upper limb coordination, response speed, visual motor control, and upper limb speed and dexterity. The BOT produces three scores. One score for gross motor ability, a second for fine motor ability, and a third battery composite score which is compiled using all eight subtests.

An abbreviated version of the BOT, called the Short Form (BOT-S), was designed to provide testors with a general analysis of a child's motor performance. The BOT-S is useful when testing large numbers of individuals, when quick assessments are necessary, or when individuals are tested by a variety of disciplines in a short period of time. The BOT-S consists of the original eight subtests with 14 selected test items.
Problem Statement—Need for Research

No research was found to exist regarding the use of the BOT with adult populations in physical therapy. Most likely this was due to the lack of available norms above 14.5 years of age. Therefore, personal interviews were conducted with clinicians who use the BOT as a clinical assessment tool for evaluating adult TBI patients (Appendix A). These interviews revealed that clinicians use the BOT because it is a comprehensive motor ability assessment which can be performed in a short amount of time and that it provides objective test results for documentation. However, without normative values, the BOT test results have limited interpretive value for clinicians. Presently, the test scores have no immediate meaning to a therapist during the patient's initial evaluation. Therapists are only able to use the scores for future reference when the patient is reevaluated to determine progress. The utility of the BOT would increase if a clinician had the ability to compare a patient's motor performance with age-appropriate standards. Clinicians could utilize these standards as a basis for documenting the existence and severity of impairments and limitations.

This study will begin to gather the descriptive data needed for developing norm tables on the BOT-S using males from 25 to 30 years of age. As previously stated, this age group of males experiences a high incidence of TBIs
secondary to high risk behaviors and sports-related activities.

Aims and Purpose

The purpose of this study is to establish standards of performance on the BOT-S using normal, healthy males from 25 to 30 years of age. Our aim is twofold: 1) to provide physical therapists with an estimate of normative values until national norms become available and 2) to share our research data with Dr. Bruininks in hopes that it will contribute to future standardization programs.

Benefits and Significance to Physical Therapy

Our study is intended to increase the significance of the BOT-S as a clinical assessment tool by providing estimated norms which will allow clinicians to interpret the meaning of test scores. Such information is beneficial as physical therapists strive to restore age-appropriate motor function during rehabilitation of the TBI patient. Standardized test results can help highlight specific deficit areas, thus providing clues as to which neurological systems are most impaired. This knowledge is beneficial when physical therapists design the emphasis of their treatment programs. Additionally, normative research using adults may provide important information regarding the characteristics of adult motor proficiency which could lead
to an adult adaptation of the BOT. Lastly, standardized 
motor assessments used in studies of neurological 
dysfunction help researchers to understand the processes of 
motor recovery and the physical therapy treatment 
interventions that promote a return to age-appropriate motor 
ability (Haley et al, 1990).

Problems with Using the BOT

A problem with using the BOT as a clinical assessment 
tool is that the BOT is not functionally based. The results 
can only serve as guides for identifying the underlying 
causes of the patient's functional status. According to 
Butler and Schenkman's (1989) model for analyzing 
dysfunction in neurological patients, impairments such as 
faulty balance and poor coordination lead to disabilities in 
daily life. Clinicians should be advocates of goal setting 
that relates to a patient's inability to function in daily 
life, such as gait deviations, inability to transfer, 
ability to perform household duties and job 
responsibilities (Butler and Schenkman, 1989). However, 
evaluating and understanding the impairments that lead to a 
particular disability results in more effective therapeutic 
treatment because the therapist can direct treatment 
toward the underlying causes of a patient's disability 
(Butler and Schenkman, 1989).
CHAPTER 2
LITERATURE REVIEW

Uses of the Bruininks-Oseretsky Test of Motor Proficiency

The Bruininks-Oseretsky Test of Motor Proficiency (BOT) was developed to assess the motor skills of school aged children, to develop and evaluate motor training programs, and to assess serious motor dysfunctions and developmental handicaps in children. Normative data was compiled for normal, healthy children ages 4.5 to 14.5 years. The test is intended for use by educators, clinicians and researchers (Bruininks, 1978).


Through extensive research (Bruininks, 1978), Dr. Bruininks began to identify significant indicators of motor development and aspects of motor performance in children. Of these, nine were chosen as distinct indicators of gross
and fine motor skills to direct test construction. They are as follows (Bruininks, 1978):

Gross Motor Ability:

1. Gross Motor Speed: the ability to maintain a high degree of speed during a brief shuttle run.
2. Static Balance: the ability to maintain body equilibrium while stationary.
3. Performance Balance: the ability to maintain body equilibrium while moving.
4. Coordinated Movements: the ability to coordinate to hands and feet in simultaneous or sequential movement patterns.
5. Strength: the ability to perform tasks requiring the use of certain arm, leg, and abdominal muscles.

Gross and Fine Motor Abilities

6. Visual-Motor Coordination: the ability to coordinate visual tracking with both gross and fine movements of the arms, hands, and fingers.
Fine Motor Ability

7. Response Speed: the speed with which a hand stops a moving visual stimulus.


9. Upper-Limb Speed and Precision: the ability to move the arms and hands quickly with manipulative dexterity and precision.

From these nine areas, 100 test items were developed. After item analysis programs, test-retest and interrater reliability studies, 46 test items grouped into 8 individual subtests, were selected for the final edition.

Each subtest was designed to measure a distinct aspect of motor proficiency; therefore, normative indices exist for each subtest. Additionally, three composite scores with respective norms were designed. Subtests one through four measure gross motor skills with their sum yielding a Gross Motor Composite score. Subtests six through eight measure fine motor skills with their sum yielding a Fine Motor Composite score. Lastly, the sum of all eight subtest scores yields a Battery Composite score. Subtest five measures both fine and gross motor skills and is considered only in the Battery Composite score.
The BOT and the BOT Short Form (BOT-S), see Appendix B, have been evaluated by researchers as well as being used as a research tool in several studies (Loovis and Melograno, 1991. Siegel et al, 1991. Lehmann et al, 1990. Walker and Green, 1982. Broadhead et al, 1982). Dr. Bruininks, the founder of the BOT, conducted several research studies to standardize and validate the BOT and BOT-S (Broadhead and Bruininks, 1983, 1982). Other researchers have also conducted similar studies directed at the BOT and BOT-S (Thomas and French, 1987. Beitel and Mead, 1982, 1980).

Broadhead and Bruininks (1982) examined childhood motor performance traits on the BOT-S. In this study the raw data from the original standardization was used to examine the characteristics of the BOT-S. These researchers found that chronological age, gender, and correlation characteristics were in line with those of the BOT. Examination of the scoring of the test items showed a limited range of possible raw scores and/or an unsophisticated scoring system on some items which resulted in a ceiling effect for older children. This may indicate a similar ceiling effect in adults as well. It should be noted that the original purpose of the test was to detect average and/or below average performance rather than very good or exceptional performance.

Beitel and Mead (1982) focused on the test-retest reliability of the BOT. They also looked for practice effects on the retest. 25 children ages three to five years
were randomly assigned to two groups with stratification for age and gender. A regression analysis showed a high rate of stability for test-retest using the short form first, followed by either the short form and/or the eight subtests. This study supported the reliability, and thus the utilization of, the BOT and BOT-S for assessment of motor skill.

Spiegel, Steffens, Rynders, and Bruininks (1990) studied the correlation between the Early Motor Profile and the BOT to examine criterion validity of the Early Motor Profile and the BOT. The Early Motor Profile is a screening edition of the Preschool Motor Scale. The Early Motor Profile is a nationally normed, comprehensive screening battery designed to identify children with disabilities or those at risk of developing disabilities. Subjects were 109 kindergarten students enrolled in a midwestern suburban school district. The results showed a significant correlation between the two tests, validating the use of the Early Motor Profile as a measure of motor development. Here the BOT is utilized as a testing standard and relies upon the reliability and validity of the BOT.

The BOT has also been utilized for several research projects as an evaluative tool for motor control. Bruininks himself examined the differences between normal children and children diagnosed with learning disabilities to find discrepancies in the scores on the BOT. Here he found that
those children diagnosed with learning disabilities had statistically significant lower composite scores on the BOT than normal children. (Bruininks, 1978).

Siegel, Marchetti, and Tecklin (1991) examined the age-related balance changes in hearing impaired children as compared with published norms. They used the Balance subtest of the BOT as their measurement tool. These researchers found that the mean composite score for the hearing impaired children was lower than the standard score. In addition they found that balance was not age-related in this hearing impaired population.

Another study, which focused on children with special needs, was conducted by Melograno and Loovis in 1991. They explored the effects of field-based training on teachers' knowledge and attitudes and on the motor proficiency of their handicapped students based on the BOT. The 46 students were categorized as learning disabled, mentally retarded, seriously emotionally disturbed, deaf, or otherwise health impaired as defined by PL-94-142. The researchers found a significant increase in the motor ability of the handicapped students as a result of appropriate programming.

Through studies such as that by Melograno and Loovis, and Siegel, Marchetti, and Tecklin we find that the BOT and the BOT-S are valuable measurement tools in pediatric populations. They are both valuable tools for screening and
diagnosing owing to the established validity and reliability in childhood populations. Yet the utilization of the BOT and BOT-S in adult populations has yet to be fully explored.

The BOT has also been utilized for research in adult populations even though there exists no norms. Walker and Green (1982) used the BOT to examine the motor proficiency and attentional-task performance in psychotic patients. They stated two reasons for choosing the BOT. First, the absence of a comparable standardized battery for adults that screened a variety of basic motor skills. Second, a version of the BOT had been used previously in research that found motoric deficits in subjects at risk for psychopathology (Erlenmeyer-Kimling, Kestenbaum, Bird, and Hilldoff, 1980). Pilot testing indicated that the test was adaptable to adult subjects with no ceiling effects. Intersubject variability, retest reliability, and interrater reliability were all found to be adequate. Based on their results, Walker and Green proposed that sustained attention performance is related in part to poor motor abilities. High risk children for psychotic behaviors showed significantly lower motor abilities on Walker and Green's version of the BOT.

Therefore, the BOT may serve as a useful motor screening tool in healthy and impaired adult populations. One group of patients that the BOT may be helpful for testing motor coordination and control is patients who have sustained traumatic brain injuries (TBIs). Based on our
interviews with clinicians (Appendix A), the BOT can be used as a sensitive screening tool for adult TBI patients. However, no research studies have been conducted on this injured population, nor have any normative values been established for healthy adult populations.

Evaluation Of TBI Patients

Much research has been conducted focusing on the traumatic brain injury (TBI) patient. The multifaceted challenges which face these patients lends itself to clinical research in all health care dimensions. Physical therapy, as a profession, has conducted a number of clinical research focusing on the evaluation, care, and progression of the TBI patient. In part, these studies attempt to better address these three vital components of the TBI patient's rehabilitation.

Roa and Kilgore (1992) compared two commonly used brain injury assessment scales with a comprehensive functional scale in their capability to predict return to work in an adult population who had sustained TBIs. 57 TBI patients were evaluated upon admission and discharge using the Patient Evaluation and Conference System (PECS), Disability Rating Scale, and Levels of Cognitive Functioning Scale. Roa and Kilgore found that these scales predicted return to work with 73.5% to 84.4% accuracy. Of the scales, the Total PECS and PECS Cognition scores were the most accurate. This
project, however, utilized a small suburban population with little social or ethnic diversity. The high percentage of accuracy in prediction of outcome does lend credibility to the usefulness of this scale. Although attempting to objectify the areas of evaluation the well devised functional nature of the test does not lend itself to objective, hard data or to comparison with a healthy population. This makes the test a valuable clinical tool but falls short for research or reimbursement purposes.

One study attempting to objectify the TBI patient's motor evaluation was conducted by Lehmann et al. in 1989. These researchers measured a quantitative evaluation of sway using a computerized balance plate as an indicator of functional balance in post-TBI patients. Normative values were used for comparison and test-retest reliability of the tool was established. Different stance positions were used as well as differing surfaces and presence or absence of visual cues. When all balance subtests were used even subtle balance deficits could be detected. The results also correlated with other clinical observations as well as the patient's reported perceptions of balance. The authors emphasized the objectivity and quantifiability that this test provided. Justification for therapeutic intervention can also be drawn from this evaluation tool. The drawback of this tool is the cost of the technology required. A Kistler multicomponent force measurement platform interfaced
with a computer was used. Furthermore, although balance is a major component and indicator of a TBI patient's functional ability, it is but one facet of the overall motoric impairments seen in TBI patients.

In attempts to better evaluate TBI patients' status, some physical therapists have opted to develop their own assessment tools. One such example is the Lakeshore Traumatic Brain Injury Scale developed by Myerly, Dillon, and Hilbers of Birmingham, Alabama (1991). The Mobility Scale is one section of the scale used to reflect patients' functional ability, document progress, facilitate integration of therapies, and communicate effectively with physicians and families. The Mobility Scale describes eight functional levels. Terms used to label the level of achievement, such as poor and good, are defined within the scale. Although scales such as this are pertinent and helpful in the TBI patient's treatment, they remain subjective and provide no comparative information with respect to a normal population.

The BOT could serve both as a more comprehensive motor skill evaluation and provide a norm-based reference for comparison of TBI patients and the normal population. The ability the BOT possesses in measuring motor control should not be understated. Motor control and motor function involve complex neural networking not yet fully understood.
It follows that objective measurement of motor control and function are difficult.

**Conceptual Framework-Motor Control**

Motor control is "a field of study covering the sensory, perceptive, and motor functions" (Brooks, 1986). Schmidt theorized that we achieve this control via the use of motor programs which are "abstract codes or structures that, when executed, result in movement" (Schmidt, 1988).

There are three reasons why motor control scientists believe that movements are controlled by programs:

(a) the slowness of the information-processing stages, (b) the evidence for planning movements in advance, and (c) the findings that deafferented animals and humans can show only slight decrements in skill. (Schmidt, 1988)

This is not meant to infer that feedback is not an important aspect of movement. Feedback occurs before, during, and after an executed movement. Before the movement occurs the initial position is fed-forward as well as being utilized to perhaps tune the spinal apparatus. During the movement feedback is used to either monitor for the presence of error or used directly in the control of movements reflexively. After the movement feedback is used to
determine the success of the response and contribute to motor learning. (Brooks, 1986)

Earlier many motor control theorists such as James (1890), Lashley (1917), as well as more recent theorists as Henry and Rogers (1960), Schmidt (1978), and Brooks (1979) believed that motor programs worked in the absence, or with minimal input from feedback during a task. One fault in this thinking is storage. If each motor task had its own motor program the neural storage required would surpass central nervous system capability. Secondly, this thought does not allow for the execution of novel tasks. For these reasons the motor program is now thought to be generalized, containing an abstract code about the order of events, the phasing or temporal structure of the events, and the relative force with which the events are to be produced. (Schmidt, 1988)

The generalized programs, however, require preprogrammed parameters from which the specifics of how the movement is to be expressed. These include the following seven types of variables: 1) the spatial-temporal pattern of muscle activation, 2) guidance of the object that requires the most attention, 3) the temporal sequence of the length-tension relationship needed, 4) timing of force application and termination, 5) speed of force application and changes in speed (velocity), 6) the degree of stiffness in joints involved in the movement, and 7) setting reflex
threshold adjustments such as the level of sensitivity in muscle spindle fibers. (Brooks, 1986)

Motor control can be viewed as either open loop or closed loop. Open loop control operates in a feedforward mode and is not feedback dependent. Instructions are structured in advance and are executed without regard to the effects they may have on the environment. (Schmidt, 1988) Open loop systems are used for ballistic and highly skilled movements. Closed loop operate in a sensory feedback mode. This ongoing feedback initiates and continuously controls movements. This system is used for novel and slow ramp movements. (Schmidt, 1988). The majority of motor tasks performed for daily activities rely on a combination of open and closed loop control systems.

Summary and Implications

Although evaluative tools exist for the TBI patient, no objective scales of motor control or motor skills exist for adults in which normative values have been determined. According to the study by Walker and Green (1982) the BOT can be utilized for an adult population without a ceiling effect. Normative data on the motor skills of normal adults could be invaluable to health care workers in their treatment and evaluation of TBI patients. This data can be used to determine and compare patients' capacities to that of the healthy population and thus predict success for
return to function. Currently there are no normed scales for this population. In an attempt to address this need our study will investigate BOT scores for adult males age 25 to 30 years.

Hypothesis

1) An average standard score for healthy males 25 to 30 years old on the BOT-S will be higher than the normed scores available for 14 year olds. This difference will be statistically significant to the p<0.01 value.

2) A ceiling effect will exist in the standard scores obtained by 25 to 30 year old healthy males on the BOT-S.

Research Questions

1) What are the standard scores for 25 to 30 year old healthy males on the BOT-S in our sample?

2) Is there a ceiling effect when BOT-S is used on adult males age 25 to 30 years?

Definitions

BOT= Bruininks-Oseretsky Test of Motor Proficiency.
BOT-S= Bruininks-Oseretsky Test of Motor Proficiency Short Form.
TBI= traumatic brain injury.
CHAPTER 3
METHODODOLOGY

This research project is a pilot normative study of the BOT-S. Presently, no normative data exists for individuals above the age of 14.5 years, yet this test is administered by physical therapists to assess adult patients with TBIs (interviews, Appendix A).

When establishing standards of performance, normative study samples should be large, random, and characteristic of the population's heterogeneity (Portney and Watkins, 1993). Due to the small sample of convenience used for this study, this effort is only the beginning of establishing the normative information hoped for. Likewise, the results from this study will only be gross estimations of standard motor performance for males ages 25 to 30 years on the BOT-S. A full-scale standardization program is needed to provide valid norms which could be generalized to clinical populations across the country.

Population and Sample
A sample of convenience was used for this study. A total of 35 males between the ages of 25 to 30 years old
volunteered to participate and successfully completed the BOT-S. Demographically, 30 of the volunteers were Caucasian, 3 were Asian, and 2 were African American. All participants resided in the southwestern region of Michigan. This information was gathered using a demographic questionnaire, included in Appendix E. The average age was 27.5 years and the median age was 27 years. These participants were gathered from three separate sites. These sites were Powerhouse Gyms of Kalamazoo, MI, Steelcase Corporation's Wellness Center of Grand Rapids, MI, and Physical Therapy students from Grand Valley State University of Allendale, MI. The sample was restricted to normal, healthy males. The exclusionary criteria were as follows: (a) severe physical impairment, (b) a learning disability, (c) below normal intelligence, (d) any chronic cardiopulmonary condition, and (e) any orthopedic condition that may have been exacerbated by the test. Exclusionary criteria "a" through "c" were established due to the findings by Dr. Bruininks that when these conditions were present, the subjects exhibited lower performance on the BOT and BOT-S (Bruininks, 1978). This information was established via personal interview and subjective report from the researchers. Exclusionary criteria "d" and "e" were established for the safety of the subjects. (Appendix C).
Instrumentation

All equipment and materials for test administration were standardized by the BOT testing kit. This kit includes the examiner's manual, individual record forms, student booklets, and testing equipment. Specialized training is not required to administer the test, however, the examiner's manual recommends that the tester become familiar with the testing directions and practice administering the test prior to the actual testing situation. Considering the above recommendation, the researchers tested 4 subjects prior to testing at the final testing sites. This was done to familiarize the researchers with the set up and administration of the BOT-S. Test-retest reliability was not deemed necessary since these are already established within the BOT and BOT-S (Bruininks, 1978).

In the BOT-S the performance of each test item is recorded as a raw score on the individual record form (Appendix B). Since each subtest measures a different aspect of motor proficiency, the test item raw scores are converted to a common set of values called point scores. This conversion of a raw score into a point score allows for the calculation of a total point score from the sum of all 14 test items. The total point scores were used to develop standard scores on the BOT-S (Appendix F). This study intends to develop a devised standard score, similar to that already established for 4.5 to 14.5 year olds, for the 25 to
30 year old male population. These devised standard scores will then be compared with the established standard scores for the 14.5 year old population as presented by Dr. Bruininks (1978).

Procedures

Prior to test administration each subject completed a health screening questionnaire (Appendix C), consent form (Appendix D), and a demographic questionnaire (Appendix E). Matching codes were assigned to the above documents to correspond with the individual record form. The master list containing names and matching codes were destroyed upon completion of the research project in order to ensure the participants anonymity.

Each subject was tested by one of two test administrators. No special consideration was deemed necessary due to the previously established intertestor reliability (Bruininks, 1978). Only one examiner and one subject were present in the testing area at one time. The area was well lit and large enough to accommodate all test items. Further modification of the environment was not controllable by the researchers. Each subject received a brief introduction and explanation of the test, as well as the purpose of this research project. The examiners administered the BOT-S according to the guidelines in the examiner's manual (Bruininks, 1978). These guidelines contain standardized instructions for each subtest. The
results were hand scored on the individual record forms and later transcribed to a Lotus 1-2-3, 2.3 statistical package. Raw data, as well as point scores, were used to determine means, medians, standard deviations, and standard scores (see Appendix F).
CHAPTER 4
DATA ANALYSIS AND RESULTS

The original hypotheses of this study were: 1) that a difference existed in the BOT-S scores for 14 year olds, as established by the BOT, and the scores of 25 to 30 year old males; and 2) that a ceiling effect existed in the scores of the 25 to 30 year old males on the BOT-S.

Comparison of Point Scores

To address the first hypothesis the current scoring method developed by Dr. Bruininks was utilized. The research study were scored on the individual test items according to the BOT manual instructions. As instructed, the point scores were calculated by summing the individual scores of each test item. The mean, median, standard deviation (SD), and range of each of the test item point scores, as well as the total point score, are reported in Table 1. Also included in this table are the maximum points allowed on each test item (labeled max points). No information on the individual test items or scores is available for the 14 year old group as reported by Dr. Bruininks (manual, 1978). To compare these two groups, the total point score was first used to determine the standard
score according the 14 year old group, the oldest age group for which normative data is available. This number is found using Table 27 (see Appendix F), on pages 132-133 in the BOT manual (1978). The mean, median, SD, range, and maximum points available are reported in Table 1 as well as labeled standard score. As reported, according to the BOT scoring method, there is a maximum standard score of 75. This figure corresponds with a point score of 87, even though the maximum possible point score is 98. To determine this standard score, Dr. Bruininks calculated the z-score of the point score values and then imposed a normal distribution to the values. This forces a mean of 50 and a SD of 10 to the data collected for the 14 year old cohort.

To compare the data collected from the 25 to 30 year old males, the point scores were used to determine a new, derived standard score. Similarly, the point scores were converted to z-scores and then conformed into a normal distribution with a mean of 50 and a SD of 10. These values are reported in Table 1.

The two values, the standard score according to Table 27 of the BOT manual (Appendix F) and the derived standard score, were compared for differences. If the two groups were truly comparable the mean and SD would be close to 50 and 10 respectively. If this were the case the values given for the 14 year olds would also be accurate for the 25 to 30
Table 1: Point Score Analysis for 25 to 30 Year Old Males on the BOT-S

<table>
<thead>
<tr>
<th>Item</th>
<th>mean</th>
<th>median</th>
<th>SD</th>
<th>range</th>
<th>max pnts</th>
</tr>
</thead>
<tbody>
<tr>
<td>running speed</td>
<td>14.51</td>
<td>15</td>
<td>1.13</td>
<td>(11-15)</td>
<td>15</td>
</tr>
<tr>
<td>standing balance</td>
<td>5.6</td>
<td>6</td>
<td>1.2</td>
<td>(1-6)</td>
<td>6</td>
</tr>
<tr>
<td>walking balance</td>
<td>3.43</td>
<td>4</td>
<td>0.99</td>
<td>(1-4)</td>
<td>4</td>
</tr>
<tr>
<td>tapping feet</td>
<td>0.97</td>
<td>1</td>
<td>0.17</td>
<td>(0-1)</td>
<td>1</td>
</tr>
<tr>
<td>jump up and clap</td>
<td>4.71</td>
<td>5</td>
<td>0.56</td>
<td>(3-5)</td>
<td>5</td>
</tr>
<tr>
<td>standing broad jump</td>
<td>14.57</td>
<td>15</td>
<td>1.42</td>
<td>(9-16)</td>
<td>16</td>
</tr>
<tr>
<td>catching tossed ball</td>
<td>2.97</td>
<td>3</td>
<td>0.17</td>
<td>(2-3)</td>
<td>3</td>
</tr>
<tr>
<td>throwing ball at target</td>
<td>2.66</td>
<td>3</td>
<td>0.47</td>
<td>(2-3)</td>
<td>3</td>
</tr>
<tr>
<td>response speed</td>
<td>7</td>
<td>5</td>
<td>3.4</td>
<td>(3-14)</td>
<td>14</td>
</tr>
<tr>
<td>drawing line</td>
<td>3.94</td>
<td>4</td>
<td>0.23</td>
<td>(3-4)</td>
<td>4</td>
</tr>
<tr>
<td>copying circle</td>
<td>1.69</td>
<td>2</td>
<td>0.46</td>
<td>(1-2)</td>
<td>2</td>
</tr>
<tr>
<td>copying pencils</td>
<td>1.89</td>
<td>2</td>
<td>0.32</td>
<td>(1-2)</td>
<td>2</td>
</tr>
<tr>
<td>sorting cards</td>
<td>7.77</td>
<td>8</td>
<td>1.74</td>
<td>(3-10)</td>
<td>10</td>
</tr>
<tr>
<td>making dots</td>
<td>8.54</td>
<td>9</td>
<td>1</td>
<td>(6-10)</td>
<td>10</td>
</tr>
<tr>
<td>total point score</td>
<td>80.26</td>
<td>82</td>
<td>6.29</td>
<td>(61-91)</td>
<td>98</td>
</tr>
<tr>
<td>standard score*</td>
<td>65.06</td>
<td>68</td>
<td>8.83</td>
<td>(37-75)</td>
<td>75</td>
</tr>
<tr>
<td>derived standard score*</td>
<td>50</td>
<td>50</td>
<td>10</td>
<td>(19-67)</td>
<td></td>
</tr>
</tbody>
</table>

*p<0.001
hypothesis supported
year old group. No further research would be necessary, as the values could be used for both populations.

Analyzing the data, it was found that when scored with the 14 year old values, the 25 to 30 year old males had an average score of 65.06 and SD of 8.83. The corresponding 14 year values would be an average score of 50 and SD of 10 owing to the imposed normal distribution of these values. To explore the difference a t-test for correlated samples was used (Popham and Sirotnik, 1973). This test was chosen because the two groups of values are correlated since the two sets of scores both are calculated from the same original point scores. To determine this a Pearson's Product Moment Correlation was found to be 0.99 using StatPak statistical package (Frisbie, 1987). Using this test, a t-value of 50.32 was found. This corresponds to a p<0.001. This value supports the hypothesis that a statistically significant difference does exist between the scores of 25 to 30 year old males and 14 year olds. To verify this, a t-test for independent samples was utilized (Frisbie, 1987). The results reinforced the difference between the two age groups.

For further visual analysis and clinical usefulness, the corresponding derived standard scores were calculated and matched to the standard scores of the 14 year olds. These scores are reported in Table 2. This table is a modification of Table 27 of the BOT manual (Appendix F;
Table 2: Comparison of Standard Scores and Derived Standard Scores (Modification of Table 27 from the BOT manual)

<table>
<thead>
<tr>
<th>14 year old point score</th>
<th>Adult Scores (actual)</th>
<th>Adult point score</th>
<th>Standard Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>87-98</td>
<td>******</td>
<td>75+</td>
<td></td>
</tr>
<tr>
<td>86</td>
<td>**</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>*</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>84</td>
<td>***</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>83</td>
<td>***</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>***</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>81</td>
<td>91</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>90</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>***</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>78</td>
<td>***</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>*</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>76</td>
<td>*</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>***</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>**</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>**</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>**</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>**</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>**</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>84</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>68</td>
<td>83</td>
<td>56</td>
<td></td>
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<tr>
<td>67</td>
<td>82</td>
<td>55</td>
<td></td>
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<tr>
<td>66</td>
<td>81</td>
<td>54</td>
<td></td>
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<tr>
<td>65</td>
<td>80</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>79</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>78</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>77</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>76</td>
<td>49</td>
<td></td>
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<tr>
<td>60</td>
<td>75</td>
<td>48</td>
<td></td>
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<tr>
<td>59</td>
<td>74</td>
<td>47</td>
<td></td>
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<tr>
<td>58</td>
<td>73</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>72</td>
<td>45</td>
<td></td>
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<tr>
<td>56</td>
<td>71</td>
<td>44</td>
<td></td>
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<tr>
<td>55</td>
<td>70</td>
<td>43</td>
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<tr>
<td>54</td>
<td>69</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>68</td>
<td>41</td>
<td></td>
</tr>
</tbody>
</table>

30
Table 2: Continued Comparison of Standard Scores and Derived Standard Scores

<table>
<thead>
<tr>
<th>14 year old point score ##</th>
<th>Adult Scores (actual)</th>
<th>Adult point score</th>
<th>Standard Score ##</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>74</td>
<td>40</td>
<td>39</td>
</tr>
<tr>
<td>62</td>
<td>73</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>71</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>70</td>
<td>34</td>
<td>33</td>
</tr>
<tr>
<td>58</td>
<td>69</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>68</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>67</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>66</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>65</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>64</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>0-52</td>
<td>0-63</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

Adult scores= scores obtained by adult subjects.
##= data taken from Table 27; p 133 of BOT manual.

Note: Modification of Table 27 of BOT manual with permission from R.H. Bruininks (1978).
Bruininks, 1978). Both of these tables may be used to directly convert the total point score of the individual tested to the standard score by finding the point score and reading over to find the corresponding standard score. This standard score can then be used to determine the individual's percentile rank and stanine (Appendix F). It may be surprising to find that the adult scores appear to be lower than those of the 14 year olds. This is misleading. Careful inspection finds that the higher adult scores correspond to lower standard scores because the adults scored overall higher. These higher scores were forced into the normal distribution with the mean of 50 and SD of 10. This in effect made it more difficult for the adults to score exceptionally well. The actual scores of the 25 to 30 year old males are reported under "Adult Scores--actual", and correspond to the point scores given for the 14 year olds. Here it is possible to visually see how high the adults would have scored using the available 14 year old standards. Overall, the new scale requires that the adult participant score higher to receive the same standard score as the 14 year old participant.

Comparison of Raw Scores

Although the point scores for the 14 year old group were not available, the means and SDs for the raw scores of
14 year old males on the BOT-S were reported by Broadhead and Bruininks (1982). These values are reported in Table 3. The corresponding scores are also reported in Table 3 for the 25 to 30 year old males. Although the ranges were not available for the 14 year old cohort, these were reported for the 25 to 30 year old group. The raw scores for the standing broad jump are not reported due to the scoring used. To measure this, Dr. Bruininks used inches. When these researchers measured the scores of the research group, the provided BOT scoring was used. This technique was devoid of linear measurement and could not accurately be converted into inches.

Unfortunately, further data analysis of this difference was uncertain since the raw data of the 14 year old group were not available. However, it is of interest to explore these values. The most marked differences found in this study were the adult scores of the running speed and agility, response speed, and the Upper Limb Speed and Dexterity subtest (sorting cards and making dots). The adults scored notably better on all these test items. Furthermore, for the Visual-Motor Control items the adult scores showed less variability (smaller SDs) than the 14 year old group. There was actually greater variability in the adult scores of the Upper Limb Speed and Dexterity items, yet the means are visually higher in the adult group. In the card sort the
<table>
<thead>
<tr>
<th>Item</th>
<th>14 year olds</th>
<th></th>
<th>25 to 30 year olds</th>
<th></th>
<th>range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>SD</td>
<td>mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>running speed (seconds)</td>
<td>6.51</td>
<td>0.55</td>
<td>5.04</td>
<td>4.96</td>
<td>(4.2-6.4)</td>
</tr>
<tr>
<td>standing balance (seconds--10 max)</td>
<td>9.61</td>
<td>1.5</td>
<td>9.46</td>
<td>1.84</td>
<td>(2.19-10)</td>
</tr>
<tr>
<td>walking balance (steps--6 max)</td>
<td>5.09</td>
<td>1.16</td>
<td>5.49</td>
<td>0.99</td>
<td>(3-6)</td>
</tr>
<tr>
<td>tapping feet (pass/fail)</td>
<td>0.74</td>
<td>0.45</td>
<td>0.97</td>
<td>0.17</td>
<td>(0-1)</td>
</tr>
<tr>
<td>jump up and clap (number of claps)</td>
<td>3.39</td>
<td>0.89</td>
<td>5.00</td>
<td>0.83</td>
<td>(3-6)</td>
</tr>
<tr>
<td>standing broad jump (inches)</td>
<td>64.96</td>
<td>11.51</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>catching tossed ball (number caught/5)</td>
<td>5.00</td>
<td>0.00</td>
<td>4.97</td>
<td>0.17</td>
<td>(4-5)</td>
</tr>
<tr>
<td>throwing ball at target (number hit/5)</td>
<td>4.43</td>
<td>0.66</td>
<td>4.54</td>
<td>0.69</td>
<td>(3-5)</td>
</tr>
<tr>
<td>response speed (Bruininks score)</td>
<td>11.7</td>
<td>2.74</td>
<td>7.39</td>
<td>3.39</td>
<td>(3-14)</td>
</tr>
<tr>
<td>drawing line (errors)</td>
<td>0.39</td>
<td>0.94</td>
<td>0.06</td>
<td>0.23</td>
<td>(0-1)</td>
</tr>
<tr>
<td>copying circle (accuracy)</td>
<td>1.61</td>
<td>0.5</td>
<td>1.89</td>
<td>0.32</td>
<td>(1-2)</td>
</tr>
<tr>
<td>copying pencils (accuracy)</td>
<td>1.74</td>
<td>0.62</td>
<td>1.89</td>
<td>0.32</td>
<td>(1-2)</td>
</tr>
<tr>
<td>sorting cards (number/15 sec)</td>
<td>25.83</td>
<td>7.23</td>
<td>34.51</td>
<td>7.29</td>
<td>(13-48)</td>
</tr>
<tr>
<td>making dots (number/15 sec)</td>
<td>38.39</td>
<td>7.57</td>
<td>52.77</td>
<td>11.18</td>
<td>(31-87)</td>
</tr>
<tr>
<td>number of subjects</td>
<td>23</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Data for 14 year old males taken from "Childhood Motor Performance Traits on the Short Form Bruininks-Oseretsky Test" by G.D. Broadhead and R.H. Bruininks, Oct. 1982, Physical Educator, (39)3, 149-55.
adults averaged more than 8 more cards in the 15 second period. Furthermore, in the dot making test the adults averaged over 14 more dots in the 15 second period.

Evaluation of Ceiling Effect

Both the point scores and the raw scores can be used to evaluate the second research question. This question addressed the existence of a ceiling effect with the adult population in the scores of the BOT-S. Broadhead and Bruininks (1982) proposed that a ceiling effect existed in the older children when tested with the BOT-S. Yet, he gives no definition of how this was found in this study. This is the same area of difficulty these researchers found. According to Portney and Watkins (1993), ceiling effect occurs when "a measurement scale is incapable of accurately recording values above or below a certain level." During the administration of the BOT-S to the 25 to 30 year old group the researchers subjectively found that often the BOT-S lacked the opportunity for variability in the tasks to be evident. For example, in the ball toss, only one individual did not successfully catch all five of the trials. The one individual who did not catch all five, had successfully caught four of the five. If the number of tosses was increased there would be an increased chance to detect the variability which may, or may not, be present. Another method of examining the presence of ceiling effect could be
the viewing of the point scores. Here we found that in ten of the fourteen test items, the median score was equal to the maximum points available. This means that over half (at least 18 of the 35 volunteers) of the adults tested scored the maximum points.

Another method of evaluating these ceiling effects is the use of percentages. It was found that high percentages of the participants scored beyond the ceiling available for point scores. Ceiling effects were noted in the running speed test as well as in the jump and clap, sorting cards, and making dots items. For running speed and agility, the raw score ceiling is set at below 5.5 seconds. 80% of the sample scored below the ceiling. However, all subjects scoring below 5.5 seconds received the same point score of 15 points (see Appendix B). Interestingly, the sample's average raw score for this test was 5.04 seconds, which is clearly below the ceiling of 5.5 seconds. Although the test challenged the adult subjects, the scoring method needs to be revised for variances to be evident.

This insensitivity was also found in the jump and clap test. The raw score ceiling for the jump and clap test is above four claps. The mean raw score was five claps. 77% of the subjects were able to clap more than four times; 49% clapping five times and 28% clapping six times. Again, all 77% of the subjects scoring above four claps received the same point score of 5. Less of a ceiling effect occurred in
the sorting cards and making dots test items. Only 14% of the subjects scored above the ceiling in the card sort, while 11% scored the ceiling in the making dots test item. By visual observation it was clear that these two test items were motorically challenging for the adult subjects. Thus, test item reconstruction may not be warranted here, but rather simply an extension of the raw score and point score range. This extension of the ranges may further differentiate adult motor performance on the BOT-S.

For the test items with test design characteristics which prohibited scores above the ceiling, the percentage of the sample that scored "at the ceiling" of the raw score scale will be reported. For the standing and walking balance test items, 86% and 71% of the subjects scored at the ceiling respectively. By visual observation, the design of these two test items were challenging for the adult subjects. To further challenge an adult the performance trial maximums of these test items, 10 seconds for the standing balance and 6 steps for the walking balance, should be extended. An extension of the performance trial maximums may provide a more sensitive differentiation of balance motor skills with adults as determined by the BOT-S.

With regard to the upper-limb coordination subtest, 97% of the subjects received the ceiling raw score for catching a tossed ball and 65% received the ceiling raw score of five hits for throwing a ball at a target. The performance trial
maximums for these two test items is five catches and five throws. By observing subjects during test administration, these two tests did not challenge the adult subjects. Therefore, the test design, as well as the performance maximums, may need to be revised to better evaluate these skills in adults.

For the visual-motor control subtest, the percentage of the sample that received the ceiling score are as follows: 1) 94% for drawing line, 2) 68% for copying the circle, and 3) 89% for copying the pencils. The design of these test items is unlike any test items discussed thus far in the BOT-S. The drawing a line test asks the participant to draw a straight line between two lines without straying outside of the two lines. The participant's raw score is based on the number of errors made. In the sample, 94% of the subjects made no errors drawing the line, this suggests that the design of the test is too easy for adults. With regard to the other two test items, copying a circle and copying pencils, the participant is asked to draw these two figures. The participant's score is based on the exactness of their drawing as compared to the original figure. In the sample 68% received the ceiling raw score of two for copying a circle, while 89% received the ceiling raw score for copying the pencils. Again, these two test items may also warrant revision to increase the complexity of these tasks and
better discriminate visual motor control ability in adults as assessed by the BOT-S.

The final test item of interest is tapping the feet alternately while making circles with the fingers. The participant is given 90 seconds to perform the skill 10 times consecutively. The scoring method for this test item is pass or fail. Only one of the subjects in our sample failed this test. It may be possible to make this test of bilateral coordination more challenging for adults by lowering the 90 second time period or by increasing the number of consecutive taps required. These percentages of subjects scoring the maximum points allotted for each test item of the BOT-S are reported in figure 2.

Figure 2: Percentage of subjects scoring the maximum point score for each test item of the BOT-S. Test item numbers (x-axis) corresponds with BOT-S form (appendix B).

These researchers also found a ceiling effect in the conversion to the standard score using the 14 year old figures in Table 27 (Appendix F) of the BOT manual (1978). Here, there is a maximum standard score of 75. This corresponds to a point score of 87. This means that with the current available scaling a point score of 87 corresponds with the same value of a point score of 98.
These researchers found that six of the volunteers in the research group fell in this point range score (Table 2). This lowered the average standard score even more since these individuals all received a standard score of 75 according to the current scaling method.

This ceiling effect in the total point scores was also evident when all of the 25 to 30 year old total point scores are listed. This is found in Table 2, titled "Adult Scores-actual". It can be seen that the adult scores fall predominantly at the higher spectrum of the scoring range available for the 14 year olds.

Conclusions

Reviewing the results, these researchers found that a difference did exist between the scores of 14 year olds and 25 to 30 year old males. This difference was found to be statistically significant to the p<0.001 value. Although an operational objective definition of ceiling effect could not be found in literature, the researchers subjectively found a ceiling effect. This ceiling effect was found not only in the individual test items, but in the scoring process as well. The derived standard scores of the study directly correspond to the standard scores of the BOT manual and could be used to determine a new set of standard scores for this 25 to 30 year old group. These standard score values are reported in Table 2.
Previous studies by Bruininks (1978), Broadhead and Bruininks (1982), and Beitel and Mead (1982) clearly demonstrate that the BOT-S is a valid, age-related measure of gross and fine motor skills for children. In this study, a significant difference in motor performance on the BOT-S was found between 14 year olds and 25 to 30 year old males. Although ceiling effects occurred in the scoring of the adult subjects, the present version of the BOT-S is able to differentiate between the motor proficiency of 25 to 30 year males and the 14 year olds. These findings suggest that the BOT-S may be sensitive in assessing the critical aspects of adult motor proficiency. The process of estimating population values requires large samples in order to establish validity and reliability (Portney and Watkins, 1993). The sample size in this study is small, however, the findings may provide a foundation for further research to establish valid adult normative values and to investigate the need for an adult adaptation of the BOT-S.

To investigate the hypothesis, two sets of standard scores were compared. The total point scores of the
subjects were converted to standard scores using Table 27 from the BOT manual (Appendix F) for 14 year old norms. This age group was chosen since it is the oldest group for which norms are available. Another set of standard scores were derived by conforming the sample total point scores into a normal distribution as described in the BOT manual (Bruininks, 1978). A t-test for correlated samples determined that the standard scores associated with the two different scoring conditions are significantly different from each other. If future studies agree with these results, the clinical usefulness of the BOT-S as an age-related measure of motor performance increases as the physical therapist gains the ability to compare the score with adult norms instead of using the 14 year old norm values. Other professions may benefit as well. According to Walker and Green (1983) in a study with adult psychiatric patients, they chose to use the BOT-S because no comparable standardized tests for adults exist that assess basic motor abilities. An adult adaptation of the BOT-S, according to these findings, may provide such an instrument for assessing adult motor skills.

While exploring the differences in performance on the BOT-S between 14 year old males and the sample in Table 2, it was found that the adults performed better than the 14 year olds in all 14 test items except standing balance and
catching the tosses. On these two test items the adults scored lower than the 14 year old group. The magnitude of the difference in performance between the two groups on these two tests is small, in fact, one of the adult subjects missed one ball toss which lowered the mean raw score to 4.96 tosses. Otherwise, the remainder of the adult subjects scored equally as well as the 14 year old males.

When comparing the mean raw scores for each test item between the two groups, it is apparent that the degree of difference varies. Large differences were noted in the following test items: 1) running speed and agility, 2) response speed, 3) sorting cards, and 4) making dots. This suggests that the construct of these test items, as well as their range of available raw scores, are more sensitive in discriminating differences between the two groups than the other 10 test items. This indicates that not all the test items of the BOT-S are equally sensitive to motorical differences within the two age groups.

Smaller differences in the mean raw scores between the two groups occurred in the remaining 10 test items. This could appear to indicate that little difference actually exists between the two cohorts regarding these motor skills. In a study utilizing the BOT-S on 3 to 5 year olds (Beital and Mead, 1982) it was demonstrated that one subtest was not
as strongly related to age as the other 7 subtests. However, until these differences are reported in greater detail, it can be suggested that a ceiling effect in scoring may account for such a small difference between the two groups in mean raw scores. Also, it can be speculated that some of the test items were not as challenging as others, which could also account for these small differences and may warrant reconstruction of some test items for use with healthy adults. These challenges may not be present in neurologically impaired individuals, such as TBI patients. The future purpose of the BOT-S should be established prior to adult adaptation of the test items.

**Ceiling Effect and the BOT-S**

Contrary to research by Walker and Green (1983) which found no ceiling effects in the BOT-S with their pilot study with adults, the data suggests that a ceiling effect did occur. As stated previously, a ceiling effect occurs when a measurement scale is incapable of detecting values above or below a certain level. In a study by Broadhead and Bruininks (1982) with 5 to 14 year old children, they report a "leveling off" of scores with older children. Due to the differences in test item design, it is impossible to evaluate each test item for the occurrence of ceiling effect base on Portney and Watkins' (1993) definition. For
example, the standing balance test measures the participant's ability to stand on their preferred leg on a balance beam. The test has a ten second maximum per trial, meaning once the participant has successfully performed this maneuver for ten seconds the test is stopped. Therefore, the participant has the opportunity to perform at the ceiling, but no opportunity exists to perform above the ceiling.

The test items in the BOT-S which allowed the investigation of a ceiling effect with respect to the above definition are: 1) running speed and agility, 2) jump and clap, 3) standing broad jump, 4) response speed, 5) sorting cards, and 6) making dots. Of these, no ceiling effects occurred with the standing broad jump or the response speed test items. This may suggest that the test construction and scoring method for these two test items are adequate for assessing adult response speed and strength as delineated in the BOT-S. A ceiling effect was found in the remaining four tests. Although these four tests displayed ceiling effects, they appeared to challenge the adult participants.

The remaining ten test items of the BOT-S were not as challenging to the adults and showed less variability of point scores. In these remaining test items the subjects repeatedly scored the maximum points allotted. The range of
maximum points for these tests were from 65% in the throwing a ball at a target test to 97% in the tapping feet and catching a tossed ball tests. The median percentage for these was 87.5%. The overall findings indicate a ceiling effect in some test items and the need for some modification of the BOT-S if it is to be used on a healthy adult population.

Finally, although this study has limitations, it is the first of its kind to document adult performance on the BOT-S in physical therapy. In conclusion, it is hoped that the data and discussion regarding ceiling effect and test item design has been meaningful. It should be noted that although ceiling effects occurred with normal male adults, this phenomena may not be present in individuals with motor difficulties. Therefore, the BOT-S may be adequately sensitive to test adult TBI patients.

Application to Practice, Administration and Education

The BOT-S is presently being used as an assessment tool by physical therapists (Appendix A) for adult patients with traumatic brain injuries (TBIs). However, the BOT-S scores for these patients are useful only when we know where the scores fall in relation to a normal distribution of scores.
on the BOT-S for adults. This would allow the physical therapist to evaluate for age appropriate motor behavior.

Adults who have suffered traumatic head injury frequently present with significant motor sequelae. This often results in varying degrees of decreased age-appropriate physical functional ability. Of primary interest to the physical therapist is the identification of those impairments through assessment which contribute to the patient's functional disabilities. The goal of the physical therapist is to develop an appropriate treatment based on those impairments and disabilities which will help the patient regain normal motor function. The most interesting finding in the study reveals the possibility that the BOT-S may be a useful instrument for evaluating critical aspects of adult motor proficiency. Test results from a standardized adult version of the BOT-S, along with functional assessments of the patient's abilities, could be effectively interpreted and arranged to provide and overview of the patient's limitations. This information could be utilized to guide therapeutic decision making. A standardized normative database would also provide objective and quantitative information for documentation purposes and comparative follow-up.

One of the many tasks of administrators is department efficiency. The administrator is always concerned with
employee productivity and finances. Administrators may become interested in the BOT-S as a clinical assessment tool for their department for several reasons. The simplicity of the BOT and the BOT-S makes it easy to administer to patients. The BOT-S can be administered in 20 minutes and is easily hand scored. Also, the cost of using the BOT-S can be evaluated by considering: 1) the actual cost of the testing kit, and 2) the cost of preparing physical therapists to use the test. The cost of the BOT testing kit is considerably less than most high-tech equipment and since no formalized training is required to use the test, the cost of preparing therapists to familiarize themselves with the test is marginal.

With regard to education, there remains plenty of raw data collection that is needed for a formal standardization program. The standardization of the BOT was done with 756 children, thus there exists an opportunity for students to continue to gather normative data with adults.

Limitations

There were several limitations with this study. The sample size was small and not random. These factors suggest that the sample did not provide an accurate representation of the population's heterogeneity. Some of the subjects were recruited from Powerhouse Gym out of convenience and
difficulties gaining volunteers. The fact that test subjects are actively involved in exercise programs may have predisposed them to performing exceptionally well on the BOT-S. This may be true, however, one could argue that lifting weights three times a week does not ensure that someone will have exceptional visual motor control or response speed. Time and resources to conduct this study were limited which may be viewed a potential cause of some of the limitations of the sample.

A major limitation was that a comparison of the sample standard scores using only males was made with standards developed on both males and females in the 14 year old group. This comparison was necessary because no standards exist with only the 14 year old males. Also, the raw data for the study by Bruininks (1978) was unavailable. This limited the statistical analysis regarding the differences between 14 year olds and the sample. It was attempted to accommodate for this by using the information gathered by Dr. Bruininks and Dr. Broadhead (1983). However, only the raw score values were available for this study and no point score comparisons could be made. Therefore, inferences were forced to be based on less sophisticated statistics and visual observation.

Likewise, another limitation exists in the statistical interpretation of ceiling effect. No established
statistical procedure to evaluate this phenomena could be found. This once again forced the reliance upon subjective interpretation and visual observation of data and findings.

Suggestions for Modification
and Further Research

One suggestion for modification would involve acquiring the raw data for the raw scores of the 14 year old cohort from Dr. Bruininks. This information would have allowed further analysis of the similarities and differences between the two groups. Here again, time limited the research efforts. Although Dr. Bruininks was ever helpful, deadlines did not permit time to find this information.

Further research is needed to establish national norms for adults. Another suggestion for further research involves investigating the construct validity and test-retest reliability of the BOT-S using adults. Also, exploring sex differences in performance on the BOT-S with adults would be beneficial as well. In addition, similar descriptive studies investigating the entire BOT would clinically advantageous. This would be of clinical importance, since many rehabilitation therapists use individual test items to assess TBI patients.

After standardization of the BOT-S with adults, it may be interesting to study the correlation between scores on
the BOT-S and functional outcomes with TBI patients. This focus is what initially drew the researchers to this project. It is hoped in the future that the information spurred by this research will be utilized in the clinical setting. Yet, the endeavors must begin at step one. That is what the researchers hoped to have accomplished in this research project.
REFERENCES


APPENDIX A

Personal Interviews with Clinicians

Format: Three interviews with three individual clinicians were performed. The interviews were informal in nature and used open-ended questions to allow for more subjective and thorough information gathering. Interviews were set up at the convenience of the clinician and held at the facility in which they were employed.

Clinician: Debbie Thomas, PT. Debbie is a staff therapist at Mary Free Bed Hospital in Grand Rapids, MI.

How is the BOT used clinically?

On the brain injury team, of which I am a member, it is used mostly on youths. Lately, we have stopped using it (BOT). I do bits and pieces of the test, I like the coordination tests and the balance tests, except I do the balance tests on a 4" board instead (of the balance beam provided with the BOT). I find that the BOT is not that useful. If it (BOT) were normed for adults then I would definitely use it. But right now I have nothing to compare it to, so I don't use it much.

Do you use the BOT only on the BI team?

I work mostly on the BI team, so I can’t say for sure. We use it and treat mostly TBI, brain aneurysm and brain cancer patients. We don't see and stroke patients, so I can't say for sure.
How specifically do you use the BOT?

I do use the BOT for evaluations, I don't usually get to retest the patients because they get discharged too quickly.

Do you find the BOT of clinical usefulness?

It isn't all that useful, I like parts of the test to describe what level the patient is at. But not for age appropriateness. I like to use it to look at the components of the activity, but I don't use it as a basis of my treatment and activities, I like to focus more on safety issues.

What do the results on the BOT tell you?

Very little, I need to look at the components of the movements. If they can do the activities of the BOT, then they are pretty high level. You can pick up the subtle deficits they have (with the BOT).

How would normative data change the way you use the BOT?

I would do the whole test (BOT). I could use it to show the deficits they have versus age-matched normals. This could show a need for further therapy.

Would you use it for billing?

Our billing procedure is under evaluation. But with inpatient it is not usually a problem.

Any other comments?

I would push for the 4" beam, the narrow beam is not practical to be used with a TBI population.
Clinician: Stephanie Stamp, OTR. Stephanie is a staff occupational therapist with Bronson Vicksburg Hospital in Vicksburg, MI. She works primarily in the rehabilitation of TBI and stroke patients.

What types of patients do you assess with the BOT-S?

Stroke and TBI patients, mainly TBI patients.

Why do you assess these patients with the BOT-S?

I prefer to use the BOT-S as part of my initial assessment with a patient because I can get a comprehensive view of the patient's abilities quickly.

What do you think is the best asset of the BOT-S from a clinical point of view?

Well, it is very easy to administer because it requires the use of minimal testing equipment and space. With a busy clinical schedule that makes the BOT-S convenient to use. But what I like best about the BOT-S is that I can gather a lot of information about the patient's abilities in a short amount of time. In summary, I can test a wide spectrum of abilities, from balance to their ability to respond to a moving stimulus in about 20 minutes.

What kind of information do you gather about the patient using the BOT-S?

Unfortunately, the numerical score can not be compared to norms with adults. So the numerical score is only valuable when you retest the patient down the road. So
basically I look at the quality of the patient's performance and decide which areas the patient is having the most trouble with.

Is the BOT-S test results help direct your treatment programs?

Not the numerical score. But I do sometimes use the numerical score as a motivational tool for my treatment programs.

How so?

By challenging the patient to score higher on the retest. I'll tell the patient to keep working hard over the next month so he or she can get a higher score. Anyway, the BOT-S indirectly guides my treatment focus because it serves as my initial focus on where the patient's problems are. Actually, I've used to BOT-S so frequently that I can almost predict which ADL's will be difficult for the patient based on their performance on the BOT-S.

How so? Can you give an example?

Sure. If the patient does poorly on the fine motor tests then that patient will most likely have trouble buttoning a shirt or tying a shoelace.

Would you find it helpful clinically if the BOT-S were standardized for adults?

Yes, because at this point I can only use the score to document any progress the patient makes. A lot of my patients can be placed in the norm tables for children, but
it is demeaning to compare an adult patient with a child and I also want to know how that patient compares with average adults his or her age. Such a comparison would help me better understand the magnitude of the patient's deficits. In other words, how far from normal is he or she when it comes to motor performance. Also, for documentation purposes, being able to state in objective terms what you are seeing in a patient's performance motorically is a plus.

Clinician: Garry Mattox, O.T.R. Garry is the director of Rehabilitation Services at Bronson Vicksburg Hospital in Vicksburg, MI.

How do you use the BOT-S clinically?

I use it both for evaluation and retest. I usually retest my patients every one to two weeks. I use it mostly on my TBI patients, which is my primary patient load.

Why do you use the BOT-S?

I think it is easy to follow. It is a very specific test, it addresses all motor abilities and ties together all systems of the body. I find it to be a good indicator for functional abilities. It gives the therapist clues about what the patient may or may not be able to do with respect to functional abilities. Although I am not sure how we can relate visual response speed (as tested on the BOT-S) to driving a car. I like the balance tests though.
Do you feel the BOT-S can be used for reimbursement issues?

I think it is easily justified for insurance coverage by relating test scores to functional activities. Especially for safety issues, like if the person should not be driving a car.
APPENDIX C

Health Screen Questionnaire

PERSONAL HEALTH HISTORY

Date: __________

Volunteer’s name: ______________________ Age: ___

Physician ________________________________

1. Have you ever been told by a physician that you have an abnormal EKG? YES NO

2. Do you have chest pain while exercising or any other time? YES NO

3. Do you have muscle-skeletal problems such as tendonitis or chronic back pain? If yes, give location. YES NO

4. Any recent hospitalizations (within last 6 months)? If yes, what for? YES NO

5. Have you ever been told by a physician that you have: Circle.
   Cancer  Diabetes  Hypoglycemia
   Stroke  Polio  High blood pressure
   Allergies  Anemia  Heart Disease
   Pneumonia  Emphysema  Angina or chest pain
   Arthritis  Asthma  Kidney disease/stones
   Hepatitis  Cirrhosis  Rheumatic/scarlett fever
   Ulcers  Lung disease  Migraine headaches

   Other ________________________________

6. Describe any other physical limitations we should be aware of that may affect your testing performance.

7. Please list medications you are currently taking:

   Medication  What for
APPENDIX D

Consent Form

I, ____________________________________________ authorize Vanessa Koschtial or Michelle Butler to administer the Bruininks-Oseretsky Test of Motor Proficiency to me. I understand I will be tested in the following areas:

1. Running speed and agility
2. Balance
3. Bilateral coordination
4. Strength
5. Upper-Limb coordination
6. Response speed
7. Visual motor control
8. Upper-Limb speed and dexterity

I understand that these tests possess minimal physical risks and will be discontinued at any time if I become distressed in any way, develop any abnormal response, or wish to discontinue for any personal reason. I will report to the testor any signs or symptoms of distress as this will be a signal to stop the test. I understand that these test results will be used in a Master's thesis for students in the Grand Valley State University Physical Therapy program, but all names will be kept strictly confidential. I further understand that Grand Valley State University is in no way liable or responsible for the administration or research involved with this project and are no way liable for any remuneration for my time volunteered or for any repercussions evolving from my participation in this project. I also understand I may contact either testor at any time following the testing if I have any questions or concerns regarding this project. The numbers at which they may be contacted are: (616) 375-4127, (616) 457-2954; or I may contact the Physical Therapy Department at Grand Valley State at (616) 8950-3365.

Date: __________________ Volunteer: __________________________
Witness: __________________________
APPENDIX E

Demographic Questionnaire

Please check all spaces which apply to you.

1. Gender: male___ female___

2. Age: 25___ 26___ 27___ 28___ 29___ 30___

3. Race: Caucasian___ African American___
   Hispanic___ Other_________

4. Community type in which you live:
   Within city limits___
   Suburbs___
   Rural___

5. Geographic region in which you live:
   Midwest___
November 9, 1993

Vanessa Clewley
455 Sunset
Roscommon MI 48653

Dear Vanessa Clewley,

This letter grants you permission to use the Bruininks-Oseretsky Test of Motor Proficiency in your research at Grand Valley State University. American Guidance Service, Inc. is the publisher and copyright owner of the Bruininks-Oseretsky test.

We would appreciate receiving any reports generated from your study for our files. Please send them to:

Gary Robertson, Ph.D.
Vice President Assessment Services
American Guidance Service, Inc.
4201 Woodland Road
Circle Pines MN 55014-1796

Sincerely,

LeAnn Velde
Rights and Permissions Manager

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