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RESEARCH REPORT

Test Items in the Complete and Short Forms of the BOT-2 that Contribute Substantially to Motor Performance Assessments in Typically Developing Children 6-10 Years of Age

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ABSTRACT

Objectives: The objectives of this study were to determine the magnitude of association between individual subtest items of the Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2), and the respective total subtest scores and to review items on the BOT-2 Short Form. ***Background:*** The Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2), is a test used to measure gross motor proficiency in both typically developing children and children with developmental disabilities between the ages of four and twenty-one. The BOT-2 Short Form consists of fourteen test items proportionally selected from the subtests of the Complete Form. It can be used as a screening tool and takes less time to administer. ***Methods and Measures:*** A convenience sample of forty-four children (twenty-one male, twenty-three Female; six to ten years), who were enrolled at a Midwestern elementary school, participated. Data was collected in one session. The BOT-2 subtests of Manual Dexterity, Bilateral Coordination, Running Speed and Agility, and Upper Limb Coordination were administered to subjects. Subjects progressed through the subtests in random order and each subtest was graded and administered by a consistent person. Means and standard deviations were calculated for the scores on the individual subtest items. Pearson correlation tests were run to determine the magnitude of the association between the individual subtest items and the respective subtest total score; the magnitude of association was assessed to see if the items that comprise the Short Form were strongly associated with their subtest total score. ***Results:*** All items in the Manual Dexterity, Running Speed and Agility, and Upper Limb Coordination subtest were significantly correlated ($p < 0.05$) with their overall subtest score. Two items in the Bilateral Coordination subtest were not significantly correlated with the overall subtest score, one that was included on the Short Form. ***Conclusions:*** Most items on the BOT-2 subtests administered were significantly correlated with their overall respective subtest scores. However, revisions to the short form may be needed in order to include more items that are all significantly correlated with their respective subtest scores.

Background

The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP; Bruininks, 1978) was published in 1978 and was a widely used standardized measurement of motor proficiency to identify children with motor skill delays.[1] The BOTMP was designed to evaluate gross and fine motor skills in children between the ages of 4.5 and 14.5 years of age.[1] It consisted of eight subtests and was used by both physical and

occupational therapists to determine if children required school-based therapy.[1]

The BOTMP underwent revisions in 2002 and was published in 2005 as the Bruininks-Oseretsky Test of Motor Proficiency, 2nd edition (BOT-2).[2] This new revision included greater functional relevance within the test content, increased coverage of gross and fine motor skills, extended normal values through twenty-one years, improved kit equipment quality and item presentation, and better measurement for four and five year-old children. The BOT-2 is designed to be used by researchers, physical therapists, occupational therapists, and adaptive physical education teachers to screen children with possible motor impairments, assist in program adjustment/placement, assess motor intervention, and support motor impairment diagnoses.[2]

The BOT-2 consists of both a Complete and Short Form, and is comprised of four composites with eight subtests, including Fine Manual Control, Manual Coordination, Body Coordination, and Strength and Agility.[2] The Short Form consists of fourteen test items proportionally selected from the subtests of the Complete Form. The Short Form is intended to be used as a screening tool to determine if further assessment is required and as one piece of a comprehensive assessment for evaluating cognitive and academic functioning.[2] The scores for both the Complete and Short Forms are defined as total points, standard scores, percentile ranks, or descriptive categories. Age equivalent and scale scores are also provided for the Complete Form.

Dietz, Kartin, and Kopp investigated reliability and validity of the BOT-2 in a study[3] conducted in 2007. Inter-rater reliability was assessed on forty-seven children between the ages of four and twenty-one and was found to be >0.90 on the Short Form and all Complete Form subtests, except the fine motor precision subtest (r=0.86). Test-retest reliability was also examined for three groups of children on two separate occasions based on age (4-7 years, n=43; 8-12 years, n=44; and 13-21 years, n=47) with correlation coefficients ≥ 0.90 for each group for the Total Motor Composite and the Short Form. The reliability coefficients of the three composites and their respective subtests were variable.[3]

The BOT-2 Complete Form requires forty to sixty minutes to administer and is considered the most reliable measure of motor proficiency when compared to only administering select composites, select subtests, or the short form.[2] However, due to its lengthy administration time, the BOT-2 Complete Form may not be the most time-efficient assessment tool to measure a child's motor function. Despite requiring less time to administer and score, a group of researchers found that the BOT-2 Short Form is not a valid measure for assessing motor proficiency in four to six year old children due to a floor effect in which the children were unable to complete four items.[4] This suggests that a revision of the BOT-2 Short Form may be advised in order to include items that most accurately measure both gross and fine motor function.

Brahler et al[5] investigated four subtests of the BOT-2, including Strength, Balance, Precision, and Integration in 113 children (fifty-nine females, fifty-four males) between the ages of six to ten years. They found that several of the items in the BOT-2 were poorly associated with their subtest total scores, including strength (knee push-ups r=0.865, sit ups r=0.572), balance (standing on one leg on a balance beam-eyes open r=0.713, walking forward on a line r=0), precision (folding paper r=0.756 and drawing lines through paths-crooked r=0), and integration (copying a star r=0.264, copying a square r=0.232).[5] Several items demonstrated a ceiling effect.[5] The researchers found that the items that are not

strongly associated with their respective subtest score may not be a valid item for that composite subtest.[5] The authors concluded that the BOT-2 may not be effective in differentiating different motor performance levels in children within this age group.[5] The Short Form contained low yield items in the Balance, Precision, and Integration subtests, which raises the question as to whether or not the Short Form is an effective test to identify children that need further testing in these areas.[5]

This study was designed to be a continuation of the 2012 Brahler et al[5] study. These authors investigated four of the eight subtests of the BOT-2; the current study assessed the remaining four subtests. Therefore, the purpose of this study was to determine the magnitude of association between individual subtest items of the BOT-2 and the respective total subtest scores on the four subtests of Manual Dexterity, Bilateral Coordination, Running Speed and Agility, and Upper Limb Coordination of the BOT-2. The subject age range of six to ten years was chosen in order to be consistent with the Brahler et al[5] study. A secondary objective was to determine if the items on the BOT-2 Short Form demonstrate the greatest correlation with their respective subtest total score. We hypothesized that all of the individual subtest items would be at least moderately correlated to the respective total subtest scores for all four of the administered subtests. We also believed that the fourteen items that comprised the BOT-2 Short Form would have a higher magnitude of association with their respective subtest total score when compared to the items that do not appear on the Short Form.

Methods

The Institutional Review Board at the University of Dayton and the administrator and principal at the participating elementary school approved this research report.

Subjects

Subjects were a convenience sample of forty-four children in first and third grades (twenty-one male, twenty-three female; six to ten years) at a Midwestern elementary school. Informed consent forms were sent home to parents or legal guardian and were signed and returned permitting involvement. Exclusion criteria for this study were identified as children who were specified (by the parents, or the school based occupational therapists (OTs)) to have known conditions such as motor delays, a neurological or orthopedic condition, metabolic disease, or concurrently receiving therapy. The children were not screened by these investigators using standardized testing, but were identified by the parents and/or OTs report if a known condition or delay existed. The consent form included a section for which guardian concerns could be noted.

Procedures

Six University of Dayton Doctor of physical therapy students, one pediatric physical therapist, and two K-12 school OT's administered the BOT-2 skill tests. Groups of children were brought to the testing area from their classroom by grade level. There were two testing areas: one in the school gym and the other on the stage in the school cafeteria. Children progressed through the subtests in random order of availability. The OTs each administered the fine motor subtest while the three gross motor subtests were administered by one of two consistent testers. The four BOT-2 subtests in question (Manual Dexterity, Bilateral Coordination, Running Speed and Agility, and Upper Limb Coordination) were administered to subjects at four separate testing stations with two examiners each. Age, height, and BMI were recorded at the final station. Each subtest was administered to the subjects by the instructions provided in the test manual.

Data was collected in one session, and all testers were trained prior to data collection.

Manual Dexterity Measurements

The Manual Dexterity subtest contains the following five items: transferring pennies (total pennies into box after fifteen seconds), sorting cards (total cards correctly sorted in fifteen seconds), making dots in circles (total of correctly dotted circles after fifteen seconds), placing pegs into a pegboard (total pegs into pegboard after fifteen seconds), and stringing blocks (total blocks strung in fifteen seconds). Highest score was recorded representing best performance for each item and totaled for a final Manual Dexterity subtest score. Interrater reliability is .92.[2]

Bilateral Coordination Measurements

The Bilateral Coordination subtest contains seven items: jumping in place-opposite sides synchronized, tapping feet and fingers-opposite sides synchronized, pivoting thumbs and index fingers, jumping jacks, jumping in place-same sides synchronized, touching nose with index fingers-eyes closed, and tapping feet and fingers-same sides synchronized. As outlined in the BOT-2, each of the test items was scored according to number of correct consecutive tasks (each test item varied in the number of required consecutive tasks without mistake). The highest score for each item was recorded indicating best performance. Interrater reliability is .98.[2]

Running Speed and Agility Measurements

The Running Speed and Agility subtest contains five items: one-legged side hop (single side hops in fifteen seconds), two-legged side hop (side hops feet together in fifteen seconds), one-legged stationary hop (single leg hops in fifteen seconds), shuttle run (time in seconds), and stepping sideways over a balance beam (individual sidesteps in fifteen seconds). All test item scores were totaled for an overall subtest score. Interrater reliability is .98.[2]

Upper Limb Coordination Measurements

The Upper Limb Coordination subtest contains seven test items: dribbling a ball-one hand, dropping and catching a ball-one hand, catching a tossed ball-one hand synchronized, dribbling a ball-alternating hands, dropping and catching a ball-both hands, catching a tossed ball-both hands, and throwing a ball at a target. All test items were allotted one trial and given a numerical score, up to a max, based on performance. The test items scores were totaled for an overall subtest score. Interrater reliability is .99.[2]

Statistical Methods

The total point scores for each of the four BOT-2 subtests were entered into Microsoft Excel with each child's coded number in order to fit the proper formatting guidelines to be analyzed by statistical software (SPSS, v. 18.0, IBM, Somers, NY). Means and standard deviations were calculated for the scores on the individual subtest items. Pearson correlation tests were run to determine the magnitude of the association between the individual subtest items and the respective subtest total score; the magnitude of association was assessed to see if the items that comprise the Short Form were strongly associated with their subtest total score.

Results

Subject demographics are displayed in Table 1. Tables 2-5 display the means, standard deviations, correlation coefficients (r), and p-values computed for the Manual Dexterity, Bilateral Coordination, Running Speed and Agility, and Upper Limb Coordination subtests of the BOT-2. Alpha level was set at $p = 0.05$. Individual items are listed in the tables from highest to lowest correlation, and the items that comprise the Short Form are indicated. Figures 1-4 display the histogram plots for the

Table 1. Descriptive Statistics

	Mean	Std. Deviation	Minimum	Maximum
Age (years)	7.2	± 1.1	6	9
Height (inches)	48.8	± 3.7	39.5	56
Weight (lbs)	62.8	± 18.6	37.6	132
BMI (kg/m^2)	16.7	± 3.8	12.3	32.4

Table 2. Manual Dexterity: Individual Subtest Items and Total Score

Items in order from strongest to weakest association with subscale total score	Mean	Std. Deviation	*r*	*p*
*Transferring Pennies	5.3	1.357	0.784	0
*Sorting Cards	5.11	1.166	0.752	0
*Making Dots in Circles	4.5	1.338	0.73	0
*Placing Pegs Into a Pegboard	5.23	1.075	0.71	0
*Stringing Blocks	3.89	0.993	0.573	0
Manual Dexterity Total	23.93	4.438		

Note: Transferring Pennies is also on the Short Form; *= $p \leq 0.05$, statistically significant correlations

Table 3. Bilateral Coordination: Individual Subtest Items and Total Score

Items in order from strongest to weakest association with subscale total score	Mean	Std. Deviation	*r*	*p*
*Jumping in Place Opposite Sides Synchronized	1.73	1.283	0.771	0
*Tapping Feet and Fingers Opposite Sides Synchronized	2.16	1.119	0.724	0
*Pivoting Thumbs and Index Fingers	2.2	0.93	0.675	0
*Jumping Jacks	2.77	0.677	0.586	0
*Jumping in Place Same Sides Synchronized	2.91	0.291	0.51	0
Touching Nose with Index Fingers Eyes Closed	3.91	0.421	0.191	0.215
Tapping Feet and Fingers Same Sides Synchronized	3.95	0.302	0.033	0.832
Bilateral Coordination Total	19.66	3.08		

Note: Jumping in Place Same Sides Synchronized and Tapping Feet and Fingers Same Sides Synchronized are also on the Short Form; * = $p \leq 0.05$, statistically significant correlations

Table 4. Running Speed & Agility: Individual Subtest Items and Total Score

Items in order from strongest to weakest association with subscale total score	Mean	Std. Deviation	*r*	*p*
*One-Legged Side Hop	3.84	1.539	0.773	0
*Two-Legged Side Hop	5.59	1.545	0.722	0
*One-Legged Stationary Hop	6.89	2.06	0.613	0
*Shuttle Run	5.41	1.386	0.453	0.002
*Stepping Sideways Over a Balance Beam	6.27	1.264	0.42	0.005
Running Speed & Agility Total	27.91	4.95		

Note: One-Legged Stationary Hop is also on the Short Form; * = $p \leq 0.05$, statistically significant correlations

Table 5. Upper Limb Coordination: Individual Subtest Items and Total Score

Items in order from strongest to weakest association with subscale total score	Mean	Std. Deviation	*r*	*p*
*Dribbling a Ball One Hand	6.02	1.355	0.847	0
*Dropping and Catching a Ball One Hand	4.09	1.235	0.788	0
*Catching a Tossed Ball One Hand Synchronized	2.09	1.763	0.787	0
*Dribbling a Ball Alternating Hands	5.09	1.84	0.78	0
*Dropping and Catching a Ball Both Hands	4.16	1.18	0.766	0
*Catching a Tossed Ball Both Hands	3.86	1.322	0.729	0
*Throwing a Ball at a Target	2.95	1.257	0.697	0
Upper Limb Coordination Total	28.3	7.712		

Note: Dropping and Catching a Ball Both Hands and Dribbling a Ball Alternating Hands are also on the Short Form; * = $p \leq 0.05$, statistically significant correlations

corresponding subtests to visually demonstrate distribution.

Computed data for the Manual Dexterity subtest are displayed in Table 2. Means and standard deviations for the five individual subtest items and the Manual Dexterity total are shown. Correlation coefficients (*r*) were calculated between each of the five individual items and the Manual Dexterity total to determine the magnitude of association. The levels of significance for each correlation are demonstrated by the p-values. Correlation coefficients (*r*) ranged from .784 to .573, with an average *r* value of .710. All of the 5 individual items in this subtest were statistically correlated with the Manual Dexterity total score, as all *p*-values were ≤ 0.05. Transferring pennies had the highest correlation (.784) and is the only item in this subtest that is also on the Short Form. Stringing blocks had the lowest correlation ($r = .573$) but was still significantly correlated. A histogram plot with a superimposed normal distribution curve for the Manual Dexterity subtest total is displayed in Figure 1.

Computed data for the Bilateral Coordination subtest are displayed in Table 3. Means and standard deviations for the seven individual subtest items and the Bilateral Coordination total are shown. Correlation coefficients (*r*) were calculated between each of the seven individual items and the Bilateral Coordination total to determine the magnitude of association. Correlation coefficients (*r*) ranged from .771 to .033, with an average *r* value of .499. There were five of seven individual items in this subtest that were statistically correlated with the Bilateral Coordination total score, as all five *p*-values were ≤ 0.05. Two of the individual items, touching nose with index finger eyes closed and tapping feet and fingers same sides synchronized, were not statistically correlated to the subtest total, with p=.215 and p=.832, respectively. Jumping in place opposite sides synchronized was the most highly correlated, with an *r* value of .771. Tapping feet and fingers same sides synchronized was the least correlated ($r = .033$) and comprises the Short Form, along with jumping in place same sides synchronized ($r = .510$). A histogram plot with a superimposed normal distribution curve for the Bilateral Coordination subtest total is displayed in Figure 2.

Computed data for the Running Speed and Agility subtest are displayed in Table 4. Means and standard deviations for the five individual subtest items and the Running Speed and Agility total are shown. Correlation coefficients (*r*) were calculated between each of the five individual items and the Running Speed and Agility total to determine the magnitude of association. Correlation coefficients (*r*) ranged from .773 to .420, with an average *r* value of .596. All five individual items in this subtest were statistically correlated with the Running Speed and Agility total score, as all five *p*-values were ≤ 0.05. Two of the individual items, shuttle run and stepping sideways over a balance beam, had *r* values below 0.5 but were still statistically correlated to the subtest total despite these low *r* values. One-legged side hop was the most highly correlated with an *r* value of .773. One-legged stationary hop is the only one of these five items that comprises the Short Form and shows a moderate but significant correlation to the subtest total ($r = .613$). A histogram plot with a superimposed normal distribution curve for the Running Speed and Agility subtest total is displayed in Figure 3.

Computed data for the Upper Limb Coordination subtest are displayed in Table 5. Means and standard deviations for the seven individual subtest items and the Upper Limb Coordination total are shown. Correlation coefficients (*r*) were calculated between each of the seven individual items

Figure 1: Distribution for Manual Dexterity

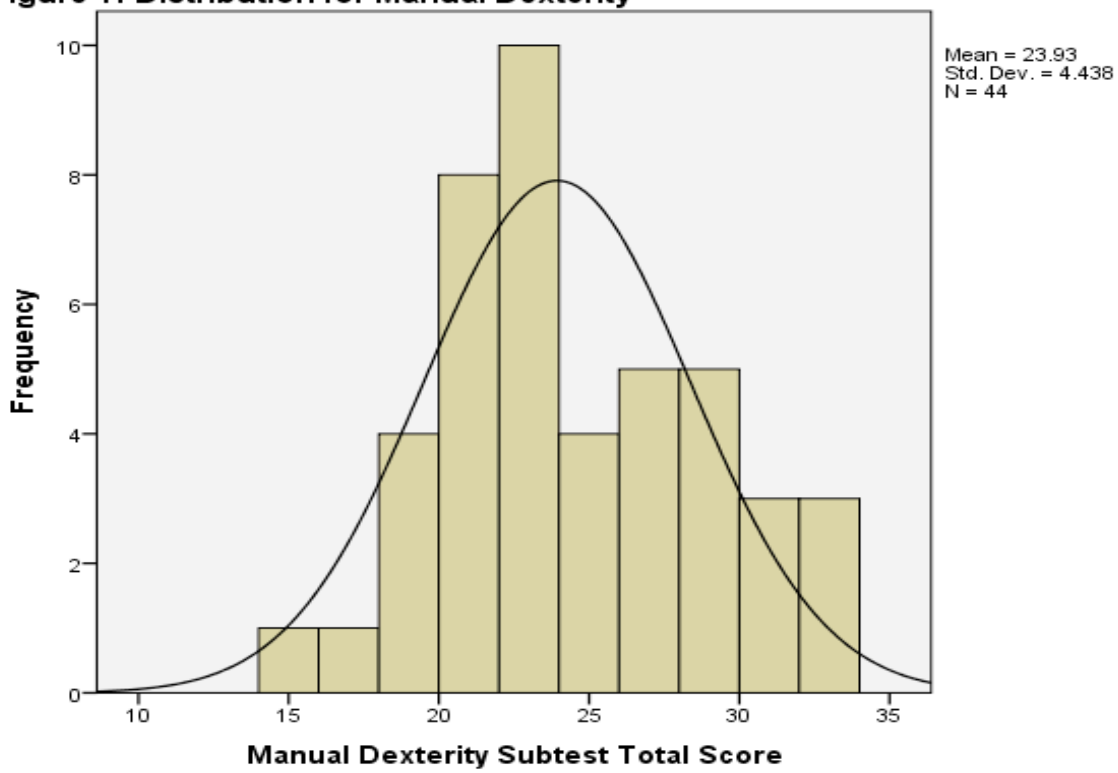


Figure 2: Distribution for Bilateral Coordination

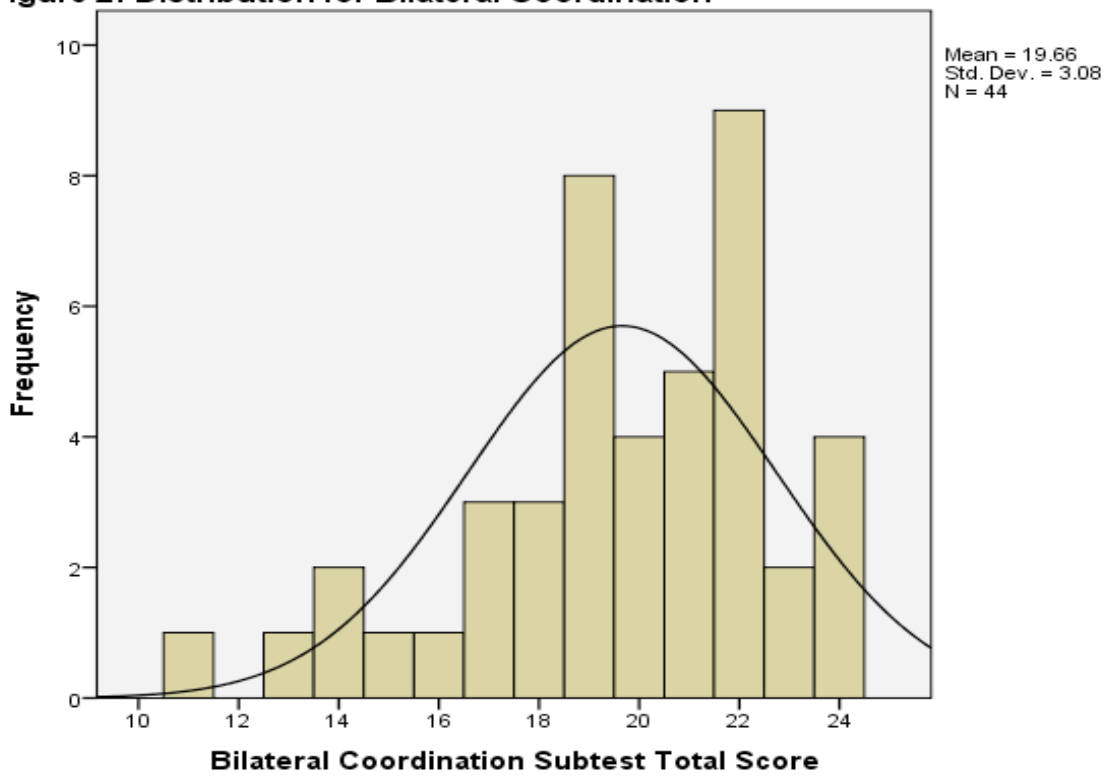


Figure 3: Distribution for Running Speed and Agility

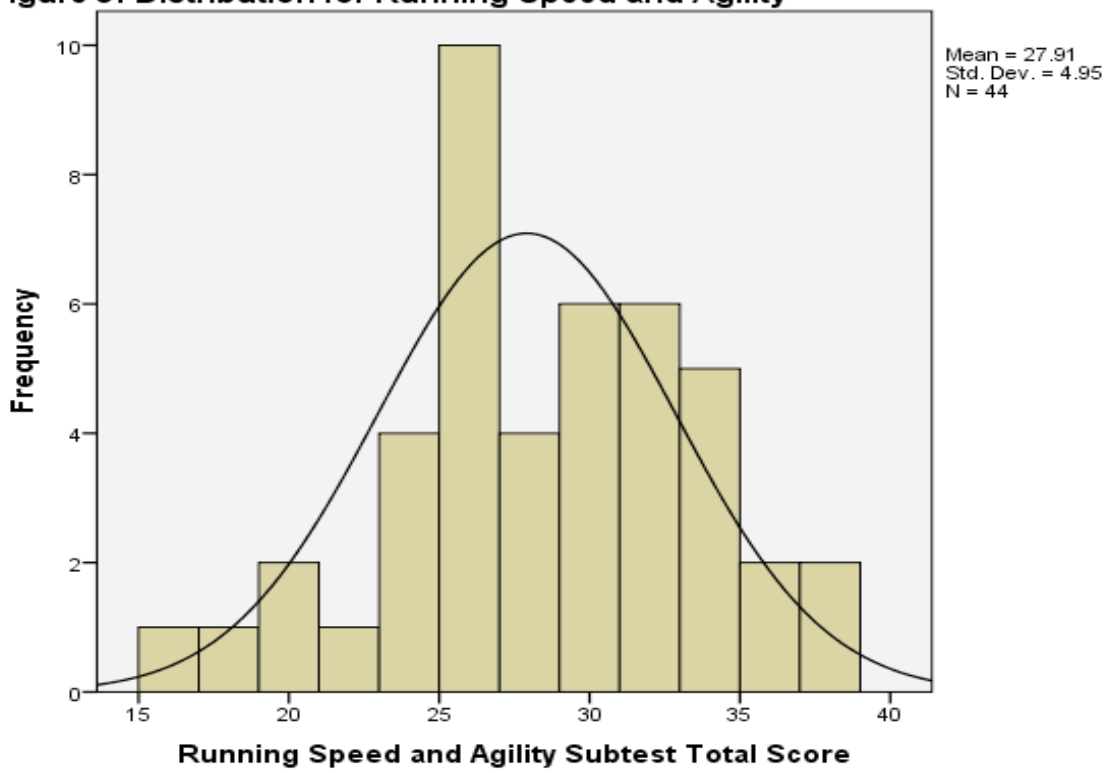
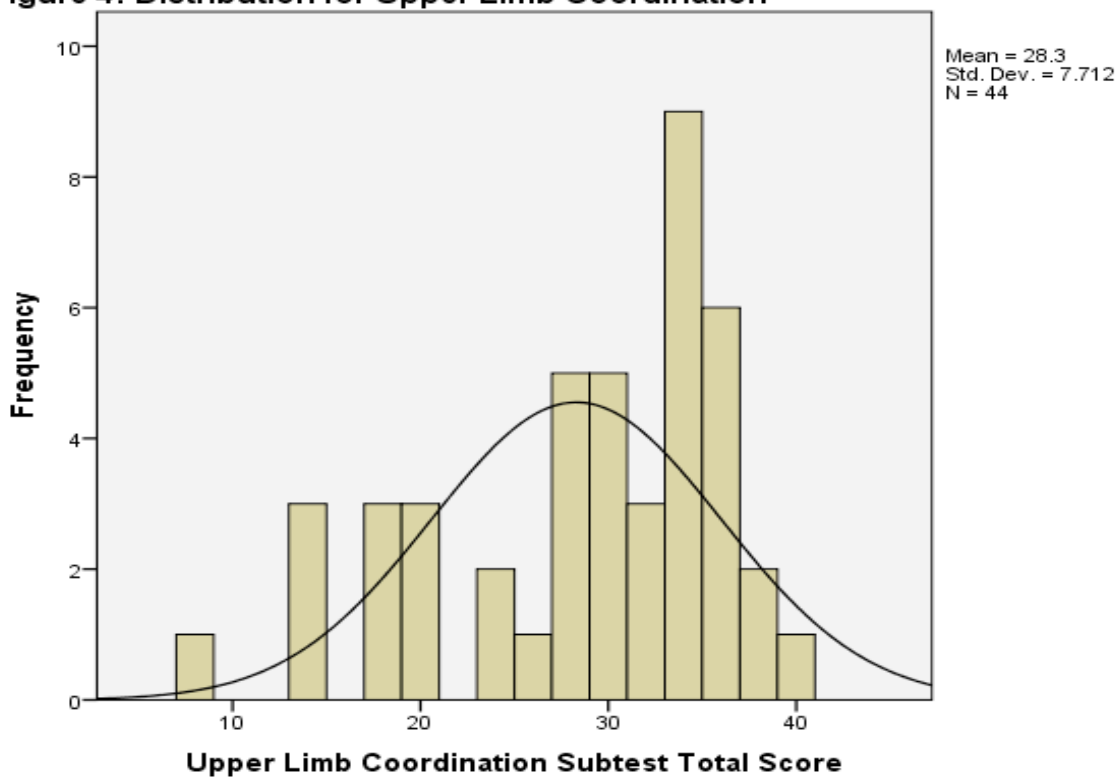


Figure 4: Distribution for Upper Limb Coordination



and the Upper Limb Coordination total to determine the magnitude of association. Correlation coefficients (*r*) ranged from .847 to .697, with an average *r* value of .771. This is the highest mean *r* value out of all four of the subtests. All seven of the individual items in this subtest were statistically correlated with the Upper Limb Coordination total score, as all seven *p*-values were ≤ 0.05. Dribbling a ball one handed was the most highly correlated with an *r* value of .847. Throwing a ball at a target was the least correlated (*r* = .697) but was still significantly significant. Dropping and Catching a Ball Both Hands (*r* = .766) and Dribbling a Ball Alternating Hands (*r* = .780) are both on the Short Form. A histogram plot with a superimposed normal distribution curve for the Upper Limb Coordination subtest total is displayed in Figure 4.

Discussion

One of the aims of this study was to examine the magnitude of association between the individual subtest items and the respective total subtest scores for the Manual Dexterity, Bilateral Coordination, Running Speed and Agility, and Upper Limb Coordination subtests. The correlation coefficient measures two variables' linear relationship strength and the higher the correlation coefficient, the stronger association there is between the individual items and the overall subtest score. For the purposes of this paper, the following definitions were used from the Portney and Watkins [6] text to determine the strength of the correlation: 0.00 to 0.025 = little or no relationship, 0.25 to 0.50 = fair relationship, 0.50 to 0.75 = moderate-to-good relationship, above 0.75 = good-to-excellent relationship. The Upper Limb Coordination individual items had the highest average correlation with the subtest total score (average r= 0.771). All of the individual tests had moderate-to-excellent correlations, which makes them valid assessments of upper limb coordination when testing children. Manual Dexterity and Running Speed and Agility had similar scores to the Upper Limb Coordination subtest (average r = 0.710 and average r = 0.596, respectively). The items in the Bilateral Coordination subtest had the lowest average correlation with the subtest total score (average r = 0.499). Therefore, all of the individual tests of the Bilateral Coordination subtest may not accurately assess bilateral coordination in children. We hypothesized that all of the individual items in these four subtests would be at least moderately correlated to the respective total subtest score. However, our hypothesis was proven to be incorrect, as two individual items in the Bilateral Coordination subtest were poorly correlated to their respective subtest total score.

The findings of this study are inconsistent with the study by Brahler et al.[5] They concluded that the individual items had a weak correlation with their respective subtest total score in the Strength, Balance, Precision, and Integration subtests. The majority of the individual items had moderate-to good-correlations to the overall scores, rather than good-to-excellent correlations as in the current study.

This study also examined the correlation of the items in the BOT-2 Short Form with their respective subtest total score. While some items included in the Short Form of the BOT-2 were significantly correlated with the overall subtest score, this study found that these items might not be the most highly correlated. Therefore, our hypothesis that all of the items were highly correlated was incorrect. Manual Dexterity's item and Upper Limb Coordination's items on the Short Form had a good-to-excellent correlation and were the highest correlated items to the overall subtest score, making them appropriate tests for the Short Form. Jumping in place-same sides synchronized

and tapping feet and fingers-same side synchronized are the two items of the Bilateral Coordination subtest on the Short Form. Tapping feet and fingers-same sides synchronized had a fair correlation with the overall Bilateral Coordination score. However, jumping in place-opposite sides synchronized had a good-to-excellent correlation and may be a better choice for the Short Form to assess bilateral coordination. While the one-legged stationary hop test had a moderate-to-good correlation, one-legged side hop would be a better item for the Short Form for the Running Speed and Agility subtest. One-legged side hop had a good-to-excellent correlation. Brahler et al [5] concluded that the items that were included on the Short Form in the other four subtests did not have a high enough correlation to conclude that they provided enough information to predict how a child would perform on that test.

There were several limitations to this study. The small sample size and the location of testing were potential limitations. Similar to the study by Brahler et al,[5] the location of testing was performed in the school gym or stage located in the cafeteria. It is possible that the children were distracted by one another when performing the tests as each test was not able to be performed in a quiet or private testing area. This could have potentially affected subject concentration when performing fine motor skills or skills such as single leg hopping, and therefore the subjects could have scored poorly in these areas. Another limitation involved the progression of testing; each child was progressed through each of the tests, but not necessarily in the order as recommended. Children were rotated through testing stations as the tests became available, in order to return them to their classes in a timely manner and to avoid long lines.

Conclusion

This study found that most items within the administered subtests of the BOT-2 were significantly correlated with the overall subtest scores. While some items included in the Short Form of the BOT-2 were also significantly correlated with the overall subtest score, these items were not always the most highly correlated. Further research is warranted with different ages and a larger sample size examining the choice of individual items included on the short form.

References

1. Bruininks R. *Bruininks-Oseretsky test of motor proficiency: Examiner's Manual.* Circle Pines, MN: American Guidance Service; 1978.
2. Bruininks R, Bruininks B. *Bruininks-Oseretsky test of motor proficiency* (2nd ed.). Minneapolis, MN: NCS Pearson; 2005.
3. Deitz J, Kartin D, Kopp K. Review of the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2). *Physical & Occupational Therapy In Pediatrics*. 2007;27(4):87-102.
4. Venetsanou F, Kambas A, Aggeloussis N, Fatouros I, Taxildaris K. Motor assessment of preschool aged children: A preliminary investigation of the validity of the Bruininks–Oseretsky test of motor proficiency – Short form. *Human Movement Science*. 2009;28(4):543-550.
5. Brahler C, Donahoe-Fillmore B, Mrowzinski S, Aebker S, Kreill M. Numerous Test Items in the Complete and Short Forms of the BOT-2 Do Not Contribute Substantially to Motor Performance Assessments in Typically Developing Children Six to Ten Years Old. *Journal Of Occupational Therapy, Schools & Early Intervention*. 2012;5(1):73-84.
6. Portney LG, Watkins MP. *Foundations of Clinical Research: Applications to Practice*. 3rd ed. Pearson/Prentice Hall; 2009:524-525.