Known-Groups Analysis of the Harris Infant Neuromotor Test
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Background and Purpose
The Harris Infant Neuromotor Test (HINT) is a screening tool designed to identify neuromotor or cognitive/behavioral concerns in infants who are healthy or at high risk between the ages of 3 and 12 months. The purpose of this study was to determine whether the HINT could distinguish between infants at high risk and infants at low risk for neuromotor delays.

Subjects and Methods
Following HINT administration by trained health care professionals, scores were compared for 54 high-risk infants and 412 low-risk infants with a t test.

Results
Mean HINT scores for infants at low risk were lower than mean scores for infants at high risk, as would be expected in that higher scores indicate higher risk. Significant differences were found at 4, 5, 7, and 8 months. At 6 months, there were no significant differences. There were not enough high-risk infants in other subgroups for reliable comparison.

Discussion and Conclusion
The HINT appears to discriminate effectively between infants who are at low risk and infants who are at high risk for neuromotor delays, supporting the use of the HINT as a screening tool for infants in the first year of life.
Although evidence regarding the effectiveness of early intervention for infants and young children with developmental delays or disability is conflicting,¹⁻³ the best hope for creating positive change for these children is to begin intervention as soon as possible. Families receiving early intervention have been shown to be better able to care for their children with special needs⁴ and have reported lower levels of stress.⁵,⁶

Neuromotor screening tests are designed to differentiate infants and children who are having difficulties in their motor development from those who are developing typically. Infants with suspected neuromotor delays then can be referred for more comprehensive assessments and specialized services, if required. Typically, follow-up programs are located in tertiary hospitals, in which only selected infants who are at high risk for developmental concerns are assessed longitudinally. A number of factors can contribute to infants being at risk for developmental delays, including preterm birth (<37 weeks of gestation),⁷⁻⁸ low birth weight (<2,500 g for full-term infants),⁹ and prenatal exposure to drugs¹⁰ or alcohol.¹¹,¹²

The Harris Infant Neuromotor Test (HINT) is a developmental screening test that was designed for administration by physical therapists, occupational therapists, family physicians, pediatricians, and community health nurses who are involved in early infant screening. It can be administered and scored in less than 30 minutes and requires very little special equipment, making the test portable. The HINT is aimed at identifying early motor delays in infants as well as early signs of cognitive or behavioral concerns. It was created for use in infants from 2.5 to 12.5 months of age.

The first edition of the HINT was assessed for content validity by an international panel of experts, whose comments resulted in the second edition of the HINT.¹³ The second edition of the HINT has demonstrated excellent interrater reliability (intraclass correlation coefficient [ICC] = .99), test-retest reliability (ICC = .98), and intrarater reliability (ICC = .98–.99).¹⁴ The HINT also has shown good concurrent validity with the Bayley Scales of Infant Development-II (Bayley-II). With Pearson r correlations, the concurrent relationship between the HINT and the Bayley-II Mental Scale was determined to be .73, and that between the HINT and the Bayley-II Motor Scale was determined to be .89.¹⁴

Compared with other infant motor assessment tools, the HINT is unique in that it includes a section comprising 5 questions to assess the caregiver's level of concern about the infant's movement and play. Early HINT research showed that parents were quite accurate in estimating whether their infant's motor development was delayed or within normal limits in comparison with standard scores on the Bayley-II Motor Scale; the sensitivity was 80%, and the specificity was 91%.¹⁵ The HINT is the first infant neuromotor screening test to have been standardized for an ethnically representative normative sample of Canadian infants¹⁶ and was designed to be administered by a wide variety of different health or early childhood professionals, such as community health nurses, general practitioners, and early childhood special educators, in addition to physical therapists and occupational therapists.¹⁷

The purpose of this study was to determine whether the HINT, an infant neuromotor screening test, could distinguish between infants who are at low risk for developmental concerns and infants who are at high risk for developmental concerns. We used the known-groups method to examine the construct validity of the HINT to address this research aim.

**Method**

**Participants**

Two groups of infants were recruited for the study using a letter of contact. Infants who were considered to be at low risk for developmental delays were recruited as part of a larger study involving normative data collection for the HINT.¹⁶ The group of infants at low risk for developmental delays were recruited from well-baby clinics, child-care centers, and community health clinics in 5 Canadian provinces (British Columbia, Manitoba, Ontario, Quebec, and Nova Scotia) through the use of a letter of contact approved by the University of British Columbia Clinical Research Ethics Board. Informed consent was obtained from a parent or guardian of each infant.

Inclusion criteria for the low-risk group were full-term birth (37–42 weeks of gestation), birth weight of greater than 2,500 g, and no history of prenatal, perinatal, or postnatal medical complications or maternal complications. Exclusion criteria for normative data collection included premature birth (<37 weeks), low birth weight (<2,500 g), a history of maternal alcohol or drug use during pregnancy, and any other high-risk medical condition for the mother or infant, such as a chromosomal abnormality or a congenital heart defect. There were 412 infants in this group, with 208 boys and 204 girls ranging in age from 2 months 16 days to 12 months 15 days.

Infants who were considered to be at high risk for developmental delays were recruited as part of a larger study evaluating the concurrent validity and predictive validity of the...
HINT.14 These infants were recruited from 2 high-risk follow-up programs in Vancouver, British Columbia: the Infants and Children at Risk Program at Sunny Hill Health Centre for Children and the Neonatal Follow-up Program at British Columbia Children's Hospital. Infants were considered to be at high risk for developmental delays because of premature birth (23–32 weeks of gestation) (n=34), low birth weight (<2,500 g) (n=28), or prenatal exposure to alcohol, drugs, or both (n=33). Thirteen of the high-risk infants also had major medical concerns, including intraventricular hemorrhage, periventricular leukomalacia, bronchopulmonary dysplasia, seizures, hydrocephalus, microcephaly, or patent ductus arteriosus; 6 others had severe meconium aspiration. Age was corrected for infants born at less than 38 weeks of gestation. Fifty-four high-risk infants (19 girls and 35 boys ranging in age from 3 months 2 days to 12 months 9 days) participated. Table 1 shows demographic characteristics for both groups.

Procedure
Groups of assessors were trained in the use of the HINT by either the principal investigator (SRH) or the project coordinator for the study (AMM). Each assessor participated in a 2-day training workshop in which an overview of infant testing and the development of the HINT was presented on the first day, followed by hands-on practice in reliably administering and scoring the HINT with 4 or 5 healthy, typically developing infants on the second day. Trainees included physical therapists, occupational therapists, a nurse, and a medical student, all of whom had previous experience in assessing infants. To evaluate interrater reliability during the HINT workshop, the course instructor and the 19 trainees simultaneously observed and scored the infants with the HINT. The HINT total score obtained by the instructor was compared with the HINT total scores obtained by the trainees, and ICCs were calculated.

The HINT consists of 3 parts. The first part is for recording background information on the child and his or her caregiver. The second part is a series of questions directed at the parent or caregiver regarding the infant's development. The final part of the assessment consists of 21 items regarding motor behaviors that are either observed or assessed through handling of the infant (eg, muscle tone). Total scores are derived from a sum of all scores for each of the 21 motor behavior items. Higher scores indicate higher risk.

Known-Groups Method for Assessing Construct Validity
The known-groups method was used to assess the construct validity of the HINT; construct validity is a type of measurement validity that reflects the ability of a test to measure a construct or abstract concept.18 The known-groups method can be used to examine differences between groups of people who are known to have a trait, such as infants at risk for developmental delays, and groups of people who do not have this trait. A criterion must be selected to identify the presence or absence of a certain characteristic that will differentiate between the groups.18 In our study, the criterion used was the degree of risk for atypical infant motor performance. In other words, we selected one group of infants who were at low risk for motor delays (full-term,
appropriately grown infants with no known medical concerns) and a second group of infants who were shown through prior research\(^7-\)\(^{12}\) to be at risk for developmental delays (infants born preterm, infants with low birth weight, or infants exposed to drugs or alcohol in utero). If differences between the groups are statistically significant, then the validity of the test for distinguishing between the groups is supported.

**Results**

**Sex Differences**

The \(t\) test calculations demonstrated that there were no significant differences between the scores for boys and those for girls for the total sample \((t=0.27, P=.79)\). From this finding, it was determined that pooled data could be used in the analysis of known-groups validity.

**Known-Groups Validity**

The \(t\) test calculations demonstrated a significant difference in HINT total scores between infants at high risk and infants at low risk \((t=-4.25, P<.001)\). In the high-risk infant group, there were only 2 infants in each of the age groups of 3, 11, and 12 months, 4 in the 9-month age group, and none in the 10-month age group, so these age groups were omitted from further statistical analysis because of insufficient numbers. For the remaining age groups of 4, 5, 6, 7, and 8 months, mean HINT scores for infants at low risk for developmental delays were lower than mean HINT scores for infants at high risk for developmental delays, as anticipated (Tab. 2). Statistically significant differences in HINT scores were found at ages 4, 5, 7, and 8 months, with \(t\) test values of \(-3.51\) \((P=.001)\), \(-2.20\) \((P=.033)\), \(-3.45\) \((P=.001)\), and \(-3.65\) \((P=.001)\), respectively. Scores did not differ at 6 months \((t=-1.72, P=.091)\).

**Discussion**

Despite the small sample of infants at high risk for neuromotor delays, the HINT was effective in discriminating between infants at high risk and infants at low risk in each of 4 different age groups \((4, 5, 7, \text{and } 8 \text{ months})\). Although differences were found in the correct direction at 6 months (that is, higher scores for the infants at high risk), the differences failed to reach significance \((P<.091)\). Group sizes for the infants at high risk in the other age groups \((3, 9, 10, 11, \text{and } 12 \text{ months})\) were too small to perform \(t\) tests \((0-4 \text{ infants in each of these high-risk groups})\).

With the 8-month age group as an example (Tab. 2), the mean total HINT score was almost twice as large for the high-risk group as for the low-risk group \((23.87 \text{ versus } 12.29)\). Nonetheless, the large standard deviation for the high-risk group \((17.87)\) indicates that some of the 15 high-risk infants performed within normal limits on the HINT. Because these infants were at high risk but had not necessarily been diagnosed as having neuromotor impairment, this finding is not surprising. Because the HINT is only a screening test, clinicians also need to continue to rely on their clinical experience and judgment in determining whether an infant has neuromotor impairment. If the decision remains uncertain, further examination with a more comprehensive assessment, such as the Bayley-III\(^{19}\) or the Peabody Developmental Motor Scales,\(^{20}\) is warranted.

Whereas the known-groups method supports the construct validity of a test, predictive validity is a type of criterion-related validity that also is essential in screening tests.\(^{18}\) Both types of analysis are important in supporting the validity of a test. Previous research on the HINT involving a sample of 54 high-risk infants showed that the predictive correlation between the HINT (administered at between 3 and 12 months) and the Bayley-II Motor Scale (administered at 17–22 months) was \(r=-.49\) \((P<.01)\), a modest relationship, suggesting that the HINT accounted for about 24% of the later Bayley-II Motor Scale outcome.\(^{14}\) Nonetheless, this relationship compares favorably with the predictive correlation between the Alberta Infant Motor Scale (AIMS), another infant motor screening test, at 6 months and the Bayley-II Motor Scale.
Known-Groups Analysis of the Harris Infant Neuromotor Test

Table 2.
Descriptive Statistics for Low-Risk and High-Risk Groups

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Risk Category</th>
<th>Sample Size (n)</th>
<th>HINT* Score</th>
<th>t</th>
<th>P</th>
<th>95% Confidence Interval</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>SD</td>
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<td></td>
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<tr>
<td>Total</td>
<td>Low</td>
<td>412</td>
<td>17.75</td>
<td>12.82</td>
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<td>&lt;.001</td>
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<td></td>
<td>High</td>
<td>54</td>
<td>25.77</td>
<td>14.44</td>
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<tr>
<td>3 mo</td>
<td>Low</td>
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<td>39.06</td>
<td>5.58</td>
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<tr>
<td></td>
<td>High</td>
<td>2a</td>
<td>37</td>
<td>3.54</td>
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<tr>
<td>4 mo</td>
<td>Low</td>
<td>45</td>
<td>33.18</td>
<td>4.6</td>
<td>-3.51</td>
<td>&lt;.001</td>
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<tr>
<td></td>
<td>High</td>
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<td>40.08</td>
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<td>5 mo</td>
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<td>26.91</td>
<td>6.32</td>
<td>-2.20</td>
<td>&lt;.033</td>
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<td>32.5</td>
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<tr>
<td>6 mo</td>
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<td>22.08</td>
<td>5.3</td>
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<td>&lt;.091</td>
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<td>25.69</td>
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</tr>
<tr>
<td>7 mo</td>
<td>Low</td>
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<td>17.45</td>
<td>5.95</td>
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<td>&lt;.001</td>
</tr>
<tr>
<td></td>
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<td>27.71</td>
<td>13.37</td>
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<tr>
<td>8 mo</td>
<td>Low</td>
<td>40</td>
<td>12.29</td>
<td>5.89</td>
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<td>&lt;.001</td>
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</tr>
<tr>
<td></td>
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<td>10 mo</td>
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<td>High</td>
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<tr>
<td>11 mo</td>
<td>Low</td>
<td>40</td>
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<tr>
<td></td>
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<td>2b</td>
<td>8.25</td>
<td>6.01</td>
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<td></td>
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<tr>
<td>12 mo</td>
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<td>3.66</td>
<td>3.19</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>High</td>
<td>2b</td>
<td>7.5</td>
<td>7.78</td>
<td></td>
<td></td>
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</tbody>
</table>

* HINT = Harris Infant Neuromotor Test.

a The number of infants in the high-risk group was too small to perform the t test for this age group.

at 12 months (r = .56)21; this time interval is much shorter than that used in the comparison between the HINT and the Bayley-II Motor Scale, that is, 6 months versus approximately 11 months. The results of both the current known-groups analysis and the previous predictive validity study14 support the overall validity of the HINT as a screening test.

The known-groups method for establishing the construct validity of a test was used previously in the investigation of other infant screening tests. Validity testing of the Test of Infant Motor Performance, a test of motor and postural control for infants less than 4 months of age, provides an example of known-groups analysis for groups of infants at low risk and at high risk for developmental difficulties but not yet diagnosed. In examining the ability of the Test of Infant Motor Performance to discriminate among 5 groups of infants with variable risks for a poor motor outcome, Campbell and Hedeker22 reported that the test was successful in discriminating between low- or medium-risk infants (groups 1 and 2) and high-risk infants (groups 3, 4, and 5). In addition, the highest-risk group, infants with brain insults (group 5), performed significantly more poorly than infants in the other 4 groups.

Fetters and Tronick23 examined the ability of the AIMS to discriminate between 28 infants with prenatal cocaine exposure and an unexposed control group of 22 infants (matched for race, family income, and maternal education level). Although there were no between-group differences on the AIMS at 1 month of age, significant differences were reported at 4 and 7 months of age.
Similarly, our validity testing compared low-risk and high-risk infants. The infants at high risk had not been diagnosed with a neuromotor delay but were at risk for such a delay. The fact that the HINT was able to discriminate between 4 of the 5 low-risk and high-risk groups, even with very small subject numbers in the high-risk group, lends support to the ongoing validation of the HINT. We are currently conducting longitudinal assessments of 100 low-risk and 100 high-risk infants with the HINT at 4–6 months and 10–12 months. The results of that research will enable us to further examine the ability of the HINT to discriminate between larger groups of infants at these time points.

Limitations

Even though the results of our study demonstrated the ability of the HINT to distinguish between infants at low risk for developmental delays and infants at high risk, there were a number of limitations that may have affected our results. The data collection for the high-risk groups and the low-risk groups occurred at different points in time, and assessors for each group were not unaware of an infant’s respective group classification. In addition, the 2 groups were unequal in size, with far fewer numbers in the high-risk group.

Conclusion

In this convenience sample, the HINT effectively discriminated between infants at high risk and infants at low risk for neuromotor delays within 4 of the 5 age levels for which there were adequate numbers of high-risk infants for comparison. Given that the HINT is a quick and easily administered screening tool that has been shown to be both reliable and valid and that can be used by a variety of different pediatric health or early childhood professionals, this finding further supports its use for screening infants during the first year of life.

References

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