

## RESEARCH ARTICLE



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# Reliability Assessment of Sensory Outcome Measure a New Developed Tool for Children with Cerebral Palsy

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## Abstract

**Objective:** To investigate the reliability of a recently developed Tool, designed for Hypoxic Cerebral Palsy Children (HCPC) to assess sensory deficits. **Method:** Internal consistency and all three types of reliability (intra-rater, test-retest, and inter-rater) were investigated. Twenty caregivers of HCPC were addressed. Principal rater took two readings for the intra-rater with a brief break, then another reading for test-retest after a seven-day interval. In the meantime, the observer took the readings for inter-rater reliability testing. The relative and absolute dependability of all three types of responses were evaluated after the recording. **Findings :** Spearman rank correlation and intraclass correlation values ranged from (0.934 to 1), demonstrating a very strong correlation. While the internal consistency was higher than desired, as indicated by Cronbach's alpha values, which ranged from (0.966 to 1). Cohen's kappa coefficient values for inter-rater reliability range from (0.048 to 0.188), and exhibited a small amount of agreement between the two observers. Standard Error of Measurement ranges from (1.026 to 3.810) and indicated credible results. All participant discrepancies on reliability testing were greater than the Minimal Detectable Change, indicating actual differences. **Novelty:** The uniqueness of this study lies not only in the selection of a recently developed tool for the assessment of sensory issues in HCPC, but also in its extensive analysis of all three types of reliability with both measures along with the assessment of internal consistency . It will be very helpful to researchers who want to create a new instrument or assess the precision of an existing outcome measure. It is the only study that offers a comprehensive analysis of each dependability approach together with the necessary statistical analysis. The Sensory Outcome Measure for Hypoxic Cerebral Palsy children is a reliable tool that has been developed for sensory testing in HCPC.

**Keywords:** CP (Cerebral Palsy); HCPC (Hypoxic Cerebral Palsy Children); SOMH (Sensory Outcome Measure for Hypoxic Cerebral Palsy Children)

## 1 Introduction

The term "Cerebral Palsy" (CP) refers to a variety of heterogeneous, non-progressive abnormalities of the developing brain. Multidimensional evaluation is crucial to identify the underlying issues affecting children with CP. Cerebral Palsy often includes sensory problems along with motor symptoms. None of the scales exhibited good psychometric properties about sensory issues in CP till date. So reliability testing of this newly developed tool named SOMH is very important for clinical perspective<sup>(1)</sup>. The tools for evaluating sensory difficulties in children with CP should be thoroughly standardized<sup>(2)</sup>. HCPCs exhibit many sensory problems along with increased motor issues. Sensory deficits like tactile, two-point discrimination and Proprioceptive senses were also seen in CP children and showed an adverse effect on gait. Two-point discrimination and stereotypy are both favorably correlated with motor abilities. So there is a need for a standardized and reliable tool for the assessment of sensory issues in CP children. A comprehensive assessment of sensory abnormalities in CP children will eventually result in an appropriate course of treatment, which will further enhance motor function as well<sup>(3)</sup>. Various reliability studies were also conducted earlier in the search of a reliable outcome measure for CP children but most of them solely focused on one domain like the Upper Extremity function<sup>(4)</sup>, assessment of balance-related tests<sup>(5)</sup>, motor power<sup>(6)</sup>, gross motor function assessment, and gait assessment<sup>(7)</sup>. However, other than SOMH, no scale has been developed yet for the Indian CPs to evaluate sensory impairments<sup>(8)</sup>.

Not only all three types of reliability (Intra rater, Inter-rater, and Test-retest) but also both measures of reliability, relative and absolute were assessed in this study which was missing in previous research<sup>(9)</sup>. Previous research on reliability either ignored any one of the important factors like SEM or simply examined one or two of its types<sup>(9,10)</sup>. In this study, where carryover, practice, or testing effects were not a factor, methods of intra-rater reliability can opt by the researcher. Test-retest reliability assessment methods are helpful for studies where there is a need of avoiding cumulative effects and measuring effects such as recall or training effects, as well as task familiarization errors. Inter-observer reliability is helpful in avoiding bias since it measures the extent to which various raters and observers provide consistent estimates of the same phenomenon<sup>(11)</sup>. We searched for two approaches for each of the three types (i.e. relative and absolute reliability). The degree to which various measurements taken by various individuals are connected is known as relative reliability. It describes how strongly repeated measurements are related. On the other hand, the fewer people's repeated measurements depart from one another; the higher the consistency is referred to as absolute reliability. No earlier studies examined both measures for all three kinds. They were focused either on one type without proper analysis<sup>(12)</sup>. This study covers every factor of reliability testing that was overlooked in earlier research. All three types of reliability were taken into consideration with both measures of reliability—relative and absolute which were absent in earlier studies. This study will be highly beneficial for researchers who plan to create a new instrument or who wish to assess the accuracy of an existing outcome measure as it analyses the reliability of a newly developed tool. The aim of study was to investigate the reliability of a recently developed Tool, designed for HCPC to assess sensory deficits.

## 2 Methodology

This was a correlation study with a "longitudinal study design". The study was conducted in the Physiotherapy Out Patient Department (OPD) of Chhatrapati Shivaji Subharti Hospital, Swami Vivekanand Subharti University, Meerut (UP). Before the study, Ethical Approval was taken from the University Ethics Committee of Swami Vivekanand Subharti University (Ethical approval no: SMC/UECM/2021/245/153). A

total of twenty (n=20) caregivers of children with CP were recruited for the study. The technique of sampling was “Convenience sampling”. CP Children those who came to the Physiotherapy OPD were sent to the Pediatric department for screening for Hypoxic Ischemia. Both male and female children of age between 3 to 14 years were included in the study. Before the study, written informed consent was taken from the caregiver of all participants. CP children whose cause of the disease was other than hypoxic ischemia were excluded from the study. The Deaf and blind children were also not included in the sensory testing.

## 2.1 Procedure

The study started on September 16, 2021, and ended on October 18, 2021, with the last sample being recognized. After being screened according to the selection criteria, 20 caregivers of HCPCs were chosen for the scale's reliability testing. Written informed consent was also taken before starting the study. Anthropometric measurements such as age, height, and weight were taken for the recruited HCPC before the scale's reliability testing. Before reliability testing, the tool has already been validated. The positive and negative symptoms found in HCPC, it was separated into two parts (Part A and Part B). Both the individual portions and the total readings were examined for correlation.

### (a) Intra Rater Reliability

As carryover, practice, or testing effects were not a factor, intra-rater reliability of the SOMH was established by measuring the scale in HCPC twice, with brief intervals in between to allow for fatigue from the prior session by the same rater. Sensory impairment readings were taken on the same day, with a one- or two-hour interval between them. The readings were taken on the same day by the same rater<sup>(13)</sup>.

### (b) Test-Retest Reliability

The test-retest reliability of SOMH was calculated by the Ph.D. candidate (same rater) delivering the scale in HCPC under similar testing conditions to the previous session on two separate occasions after a seven-day break. The testing was done on the first day and then after again on the seventh day (by the same rater). This measurement theory concept called test-retest reliability measures how stable a measure is when repeated measurements are made. This is crucial because it affects how precisely we can quantify relationships with other relevant factors as well as how precisely we can characterize an object<sup>(13,14)</sup>.

### (c) Inter-Rater Reliability

Inter-Rater reliability refers to the degree to which two or more persons agree. For the investigation of inter-rater reliability, two raters took readings. The Principal Investigator and one observer took readings on the first day, then after a seven-day gap, the same two raters took readings again. The Ph.D. candidate was the First rater and participated in the study as a Principal investigator. The Observer participated in the study as the second rater and took part only in the inter-rater reliability study. The second rater (observer) did not ask any questions from the caregiver and took part in the study only as an observer and put the reading only by hearing the answer of the caregiver those which were asked by the principal investigator<sup>(15,16)</sup>.

### (d) Internal Consistency

When estimating a test's reliability based on a single administration, internal consistency is used. Internal consistency refers to how well a set of items assess a single construct as shown by how they vary from one another or intercorrelate. The composite score's high level of internal consistency allows the researcher to interpret it as a measure of the construct<sup>(17)</sup>.

## 2.2 Measures of reliability

For all three kinds, we looked for two methods:

(a) Relative reliability refers to the degree to which distinct measurements of different people are correlated. Relative reliability refers to the extent of the association between repeated measurements.

(b) Absolute reliability refers to the degree to which people's repeated measurements deviate from one another; the less they differ, the higher the reliability<sup>(18)</sup>.

## 3 Results and Discussion

1. Demographic Dimensions of Children recruited for Reliability Testing
2. Demographic dimensions of HCPCs according to gender difference selected for Reliability Testing. Male and female children recruited for the reliability study did not differ significantly in age (independent t-test,  $p>0.05$ ), but were significantly different in weight and height.
3. Analysis

### 3.1 Intra Rater Reliability

- Relative reliability (Intra Rater)
- Absolute reliability (Intra Rater)

### 3.2 Test-Retest Reliability

- Relative reliability (Test Retest)

All values of the Spearman Correlation Coefficient  $\rho$  ( $\rho$ ), ICC, and alpha measures were lies between (0.90 to 1), exceeding the cutoff for acceptable validity and good reliability<sup>(19)</sup>. The Cronbach's alpha value exceeds (0.8), which denotes a very high-level correlation<sup>(20)</sup>.

According to Portney and Watkins, ICC values above 0.75 indicate acceptable reliability, while those below 0.75 indicate poor reliability. A score of 0.75 is considered bad to moderate. To provide adequate validity, reliability for numerous clinical metrics should exceed 0.90. All of the ICC measures were more than 0.90, indicating that they exceeded the threshold for good reliability and acceptable validity. The Cronbach's alpha value was higher than 0.8, which indicates a very good level<sup>(20)</sup>.

- Absolute reliability (Test Retest)

The values of MDC vary between, 0.127 to 9.7 was indicated genuine differences<sup>(21)</sup>. SEM for intra-rater and test-retest reliability varies from 1.026 to 3.81.

### 3.3 Inter-Rater Reliability

Physical therapists frequently examine their patients in professional settings using a variety of tests and measurements. Intra-tester and inter-tester reliability is a crucial quality for therapists to feel confident using their tests and measures<sup>(22)</sup>. Psychometric qualities should be taken into account while choosing the outcome measures<sup>(18)</sup>.

For each of the three forms of reliability testing, a total of 20 patients were recruited. As the reliability study need not involve a large number of subjects usually 15–20 subjects were enough<sup>(23)</sup>.

We examined the two forms of reliability: relative and absolute. Previous studies merely addressed the technique of analysis or the kind of reliability, without clearly stating which method of analysis should be applied in the context of their type<sup>(19)</sup>. This study covers an overall comprehensive assessment of reliability.

It was advisable to consider both the relative and absolute reliability of a measuring scale before implementing it in clinical practice. The Spearman  $\rho$  ( $\rho$ )<sup>(24)</sup> was used to describe relative reliability, while SEM and MDC measurements were used for absolute dependability<sup>(15,25,26)</sup>.

### 3.4 Relative Reliability

The Spearman rank correlation coefficient ( $\rho$ ) was used because the data were ordinal. In a case where, 4- or 5-point Likert-type scales are employed to measure the association between ordinal scales, the Pearson correlation is frequently used. The degree and direction of a monotonic relationship between the numbers were measured using the nonparametric Spearman correlation test, which is a variation of the Pearson correlation. By substituting the observed scores with rank scores, it is possible to get the Spearman correlation coefficient<sup>(20)</sup>. The scale was split into two sections, each of the two SOMH segments (a total of 49 questions) was scored using an ordinal grading system with a range from 1 to 5 (Likert type). To express the SOMH reliability, the Spearman Rank Correlation coefficient was used<sup>(21)</sup>.

It is a nonparametric test. When the population is not normally distributed, when the sample size is small, and when data types like ordinal or nominal data are present, nonparametric tests perform well with skewed distributions. When analyzing these variables, nonparametric tests are the only option<sup>(27)</sup>.

For all three types of reliability, the value of spearman rank correlation ranged from (0.954 to 1) which exhibits a very strong correlation<sup>(28–30)</sup>.

For evaluating the consistency of measuring scales, ICC (intraclass correlation coefficient) is advised. However, the ICC is dependent on several statistical hypotheses, such as normality and stable variance, which are rarely taken into account in applications related to health<sup>(31)</sup>. ICC was employed the most often for reliability assessment, especially for intra- rater and inter-observer agreements<sup>(32)</sup>. It is also frequently used as the reliability index for test-retest, reliability<sup>(23,31)</sup>. The ICC is one of several statistical metrics that have been used to evaluate the test-retest reliability of functional connectivity<sup>(25)</sup>. In general, it is utilized to analyze the consistency or conformity of two or more quantitative data<sup>(24)</sup>.

To determine agreement or consistency between two evaluation methodologies, the ICC has been used. When the value is greater than 0.90, it indicates exceptional reliability and performance. Values between 0.5 and 0.75 suggest moderate reliability, 0.75 and 0.9 indicate good dependability and higher than 0.90 indicates exceptional reliability<sup>(33)</sup>. The intra-class correlation values ranged from (0.934 to 1) indicating excellent reliability<sup>(26,33)</sup>.

Observer agreement occurs in studies that evaluate reliability. The physical therapy literature has many types of research evaluating observer agreement. The statistical approach recommended by Cohen and the corresponding reliability coefficient, Cohen kappa, is most frequently employed to evaluate observer agreement studies that involve nominal or ordinal data. The kappa paradox, which happens when observer agreement is high but the resulting kappa value is low, has recently caused Cohen kappa to come under criticism<sup>(22)</sup>.

Inter-rater reliability was evaluated using Cohen's kappa coefficient. The importance of rater reliability comes from the fact that it shows how reliable the research's data are for the variables under consideration. It is a reliable statistic that may be applied to tests of intra-rater and inter-rater reliability. Similar to correlation coefficients, it has a range of 1 to +1, with 0 indicating complete disagreement and 1 indicating complete agreement between raters<sup>(16,34,35)</sup>. The values of inter-rater reliability with Cohen's kappa coefficient lie between (0.048 to 0.188). According to the values of the kappa coefficient, slight agreement (Kappa Paradox) was noted between the two observers<sup>(16)</sup>.

### 3.5 Absolute reliability

Absolute reliability is the degree by which individual frequent values deviate from one another; the lower the difference, the higher the dependability. Absolute reliability assesses the level of measurement deviation across repeated measurements. The absolute reliability was assessed using the SEM and the MDC<sup>(36–38)</sup>.

The SEM is a reliability statistic that shows how much a score varies when measured repeatedly<sup>(39)</sup>. SEM for intra-rater and test-retest reliability varies from 1.026 to 3.81, indicating reliable results; as low SEM indicates more reliable results<sup>(40)</sup> but the values of SEM were exhibited somewhat higher for inter-rater reliability than the other two types of reliability.

The MDC is referred to as the smallest modification in a tool's values that quantifies a symptom but is not a measurement error<sup>(41)</sup>. Any change in a subject's score higher than the MDC, whether above or below the preceding score, is deemed genuine. More exactly, all of the participant discrepancies on repeated testing of test-retest and intra-rater were larger than the MDC, it was indicated for genuine differences, and for inter-rater 80% of participants exhibited actual differences<sup>(21)</sup>.

### 3.6 Internal Consistency

The estimate of internal consistency reliability in research that is unquestionably most frequently reported is Cronbach's coefficient alpha<sup>(26)</sup>. Internal consistency of measure, often known as homogeneity, is a metric that can be used to assess an item's stability on a scale or in a measurement. If the scale is reliable, the score will remain consistent regardless of the order in which the items are presented. It is a commonly used metric for determining internal consistency. As a result, it was used to assess the consistency of test results across items<sup>(42)</sup>. The values of Cronbach's alpha ranged from (0.966 to 1) indicating a higher than desirable value (i.e. more than 0.7) for internal consistency<sup>(27,28,43)</sup>.

### 3.7 Limitations

1. The number of HCPCs who took part in the SOMH reliability research was small. Low prevalence, Time of spreading of Corona Virus (Social Distancing), and caregiver negligence (for physiotherapy treatment and follow-up) were the main reasons for the limitations of this tool. Even though the sample size was smaller, it was well within the Donner et al. suggested level.
2. All three types of reliability tests were carried out at a single center. As a result, it's important to be cautious when interpreting reliability. Experts from several geographical locations, however, participated in the scale content validation.
3. All three types of reliability studies were completed on the same sample, even though readings were only taken three times, giving the caregiver a lower chance of recalling the response.

#### 3.1.1 Strengths of the study

1. All three categories of reliability have been investigated and found to be consistent, indicating that the instrument is quite reliable.
2. Inter-rater reliability was carried out with the aid of another investigator which eliminate the possibility of assessor bias.
3. Both two methods were checked for all three types (relative and absolute reliability)

- Before interpreting the final results, internal consistency was also tested in addition to all three categories to ensure that no criteria were overlooked.

### 3.1.2 Further recommendations

- Ordinal scale could be converted into an interval scale so that percentage scoring could be calculated for each Domain.
- Study can be done on a large sample size
- Documentation may be done separately for each of the domains of the tool

## 4 Conclusion

SOMH, a recently developed tool exhibited excellent test-retest, intra-rater, and inter-rater reliability along with excellent internal consistency. This is a reliable tool that can be used in the Indian HCPC, for measuring sensory impairments.

**Table 1.** Description of Three types of Reliability

| Intra Rater  | Test Retest   | Inter Rater  |
|--|---|--|
| <ul style="list-style-type: none"> <li>Assessment Session 1 ( Principal Investigator )</li> <li>Short Period Break</li> <li>Assessment Session 2 ( Principal Investigator )</li> </ul> | <ul style="list-style-type: none"> <li>Assessment Session 1 (Principal Investigator )</li> <li>7 Days Break</li> <li>Assessment Session 2(Principal Investigator )</li> </ul> | <ul style="list-style-type: none"> <li>Assessment Session 1(Principal Investigator )</li> <li>Observational evaluation 1(Observer)</li> <li>7 Days Break</li> <li>Assessment Session 2 (Principal Investigator )</li> <li>Observational evaluation 2 (Observer)</li> </ul> |

**Table 2.** Demographic dimensions of the HCPs recruited for Reliability testing (n=20)

| Demographic dimensions | Mean   | Range     |
|------------------------|--------|-----------|
| Age (years)            | 5.62   | 3 to 14   |
| Height (cm)            | 104.30 | 89 to 160 |
| Weight (kg)            | 14.97  | 12 to 48  |

**Table 3.** Male and Female HCP, s selected for Reliability study demographic data

| Demographic dimensions | Male (n=12) | Female (n=8) | p-value* |
|------------------------|-------------|--------------|----------|
| Age (years)            | 8.83        | 5.62         | 0.066    |
| Height (cm)            | 125.35      | 104.03       | 0.049    |
| Weight (kg)            | 27.83       | 14.97        | 0.026    |

Demographic dimensions of male and female HCP recruited for Reliability testing (n=20)

**Table 4.** Spearman Correlation Coefficient rho ( $\rho$ ), Intra class coefficient (ICC) correlation coefficient and Cronbach's alpha in reporting intra-rater reliability and internal consistency of SOMH among the patient with HCP

| Domains | Session – 1    | Session – 2    | Spearman rho ( $\rho$ ) | ICC (3,k) 95% CI | Cronbach's $\alpha$ |
|---------|----------------|----------------|-------------------------|------------------|---------------------|
| PART A  | 87.20(30-150)  | 84.10(29-145)  | 0.998                   | 0.999            | 0.999               |
| PART B  | 52.15(19-95)   | 51.50(20-95)   | 0.964                   | 0.992            | 0.996               |
| TOTAL   | 139.35(49-245) | 138.65(54-245) | 0.995                   | 0.999            | 0.998               |

All values of the Spearman Correlation Coefficient rho ( $\rho$ ), ICC and alpha measures were greater than (0.90), exceeding the cutoff for acceptable validity and good reliability<sup>(15)</sup>. The Cronbach's alpha value exceeds (0.8), it denotes a very high level correlation<sup>(16)</sup>.

**Table 5.** SEM and MDC for two sessions of intra rater reliability

| Domains | Session – 1   | Session – 2   | SEM  | MDC  |
|---------|---------------|---------------|------|------|
| PART A  | 87.20(30-150) | 84.10(29-145) | 3.34 | 9.25 |

*Continued on next page*



Table 5 continued

|               |                |                |       |       |
|---------------|----------------|----------------|-------|-------|
| <b>PART B</b> | 52.15(19-95)   | 51.50(20-95)   | 1.026 | 2.84  |
| <b>TOTAL</b>  | 139.35(49-245) | 138.65(54-245) | 3.81  | 10.56 |

The values of SEM lies between (1.026to 3.81)indicated reliable result ,as low SEM indicates more of the reliable result<sup>(17)</sup>.

**Table 6.** Spearman Correlation Coefficient rho ( $\rho$ ), Intra class coefficient (ICC) correlation coefficient and Cronbach's alpha in reporting Test Retest reliability and internal consistency of SOMH among the patient with HCP

| Domains | Session – 1     | Session – 2     | Spearman rho ( $\rho$ ) | ICC (3,k) 95% CI | Cronbach's $\alpha$ |
|---------|-----------------|-----------------|-------------------------|------------------|---------------------|
| PART A  | 87.2(30-150)    | 87.0(30-150)    | 1.00                    | 1                | 1                   |
| PART B  | 52.15(19-95)    | 52.15(20-95)    | 0.900                   | 0.987            | 0.993               |
| TOTAL   | 139.35 (49-245) | 139.15 (53-245) | 0.993                   | 0.997            | 0.999               |

**Table 7.** SEM and MDC for two sessions of test retest reliability

| Domains | Session – 1    | Session – 2    | SEM   | MDC  |
|---------|----------------|----------------|-------|------|
| PART A  | 87.2(30-150)   | 87.0(30-150)   | 0.046 | .127 |
| PART B  | 52.15(19-95)   | 52.15(20-95)   | 1.46  | 4.04 |
| TOTAL   | 139.35(49-245) | 139.15(53-245) | 3.44  | 9.7  |

The values of SEM were between (1.04to 3.44) indicated reliable result, as low SEM indicates more of the reliable result<sup>(14)</sup>. The values of MD varies between (2.84 to 11) , indicated genuine differences between the two session<sup>(7)</sup>.

**Table 8.** Results of inter rater reliability between two raters for two repeated sessions

| S. No. | RATER 1         | RATER 2<br>(observer) | ICC 95% CI | Cronbach's $\alpha$ | MDC   | SEM   | KAPPA |
|--------|-----------------|-----------------------|------------|---------------------|-------|-------|-------|
| 1.     | 139.35 (49-245) | 135.15 (59-241)       | 0.934      | 0.966               | 68.27 | 24.73 | 0.188 |
| 2.     | 139.25 (54-245) | 136.45 (59-241)       | 0.940      | 0.969               | 65.97 | 23.8  | 0.048 |

All of the ICC measures were more than 0.90, indicating that they exceeded the threshold for good reliability and acceptable validity<sup>(11)</sup>. The Cronbach's alpha value is higher than 0.8 , it indicates a very good level<sup>(12)</sup> . The values of SEM were between (23 to 24.73) indicated reliable result, as low SEM indicates more of the reliable result<sup>(13)</sup> . The values of MD varies between (65.97 to 68.27) it was indicated for genuine differences<sup>(3)</sup> . The values of Cohen's kappa coefficient for inter rater reliability lies in between (0.048 to 0.188) according to values of kappa coefficient slight agreement was noted between two observers<sup>(4)</sup> .

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