PRELIMINARY ITEM AND SUBSCALE ANALYSIS OF
THE SEATED POSTURAL CONTROL MEASURE

by

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Abstract

The purpose of this research was to conduct a preliminary item and subscale analysis of the Seated Postural Control Measure (SPCM) to determine: 1) whether item function was consistent with the purpose of the measure; and, 2) whether the items were appropriately placed in the theoretically-derived subscales.

Statistical review of item properties including item difficulty, item discrimination, item homogeneity and item-subscale congruence was undertaken using data from the two reliability studies conducted in 1991 and 1993. Analysis of these item properties required calculation of the item difficulty index, the individual gain discrimination index and the analysis of inter-item correlations and item-subscale correlations.

Inter-item correlations suggested that item homogeneity was appropriate for all but one of the assessed item pairs. Item difficulty in the pre-seating condition was within the anticipated range for 31 of the 34 items. Item sensitivity as assessed by the individual gain discrimination index, was within the anticipated range for 22 of 34 items. Further exploration of the data revealed possible causes for the low discrimination index for 12 of the items including, high item difficulty, lack of effects of the intervention, and the occurrence of negative change which was not detectable by the discrimination index. Results of the assessment of item-subscale congruence supported the grouping of items in the Function scale and two of the four Alignment subscales. Results of the Alignment subscale-section congruence assessment supported the groupings of all subscales except the Head subscale.

Limitations of the research which affected the strength of the conclusions were: the retrospective nature of the study; the small sample size for some items; the poor reliability of some of the alignment item data used for two of the hypotheses and the possible effect of reliability on inter-item correlations; the lack of an external measure of change; and, the constraints in the interpretation of ordinal level data.

Implications of the study findings for future test development include the need to delete one redundant item, modify some items and possibly make small changes to the subscale structure.
Future research should focus on establishing the responsiveness of the measure and the minimal clinically significant score difference.
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CHAPTER I INTRODUCTION

Statement of the Research Problem

To date, no adaptive seating outcome measures exist which have been shown to be reliable and valid for the evaluation of treatment effects in children with neuromotor conditions. Although adaptive seating is widely used by occupational therapists and physiotherapists in clinical practice, the lack of proven measurement tools hampers progress in the application of this technology. Development and validation of seating outcome measures is required to provide the means of measuring the appropriateness and effectiveness of this practice.

Rationale and Justification

The call to evaluate outcomes of therapeutic interventions is critical as therapists are presented with an increasing range of treatment options, as health care funding is decreasing, and as health service consumers are taking more control of making decisions regarding their own health (Cole, Finch, Gowland, & Mayo, 1994).

Adaptive seating systems are widely prescribed, by physiotherapists and occupational therapists, for children with physical disabilities. Children who are unable to stand or walk due to the severity of their motor impairment must perform many of their daily activities from a sitting position. For those who are unable to sit independently, custom seating systems are designed to provide optimum body alignment and postural control while promoting use of the arms for a range of functional activities. Although the magnitude of the need for specialized seating in Canada has not been quantified, a comprehensive population study undertaken in the Dundee district of Scotland found 4.6 people per 1000 (N = 204,000) had specialized seating needs (Bardsley, 1984).

With advances in technology, the variety of seating systems has increased markedly over recent years expanding available options for children but also making the selection process more difficult. Therapists may now choose from simple seat cushions to complex custom molded body
supports, ranging in price from $500 to $5000. The selection process involves matching the findings from the assessment of the child's motor abilities and lifestyle with the design features of the various seating systems. Trials in the seating systems which are thought to best match the child's needs are undertaken and the effectiveness of each seating system in improving motor and functional abilities is judged subjectively. A number of seating specialists have developed guidelines for selecting categories of seating systems to match the degree of the individuals' neuromotor involvement (Mulcahy, Pountney, Nelman, Green, & Billington, 1988; Trefler, 1984). However, these guidelines were not based upon empirical evidence nor subsequently tested for adequacy of categorization.

Although adaptive seating is being used increasingly for children with neuromotor conditions, controversy still surrounds the timing of seating intervention and the relative merits of available seating options. Purported benefits of adaptive seating include enhanced physiological function (Nwaobi & Smith, 1986), improved postural control (Miedaner, 1990), improved upper limb control (Noronha, Bundy, & Groll, 1989), improved oral-motor control (Hulme, Shaver, Acher, Mullette, & Eggert, 1987), increased comfort, increased social and communicative opportunities (McEwen, 1992), and decreased incidence of secondary complications such as pressure sores (Ferguson-Pell, Cochran, Palmieri, & Brunski, 1986) and musculoskeletal deformities (Hobson, 1989). Of all the proposed outcomes, postural control is perhaps the most controversial due to the conflicting concerns of proponents and detractors of adaptive seating. Potential adverse effects of adaptive seating are thought to be a restriction of early development of postural control due to the constraints provided by the seating system. Conversely, potential benefits are thought to result from the provision of a stable support surface and limitation of proximal joint movement to a prescribed, controllable range (Tredwell & Roxborough, 1991; Ward, 1984).

Campbell (1990) underscored the potential importance of postural control as a therapeutic outcome at a recent Consensus Conference on the Efficacy of Physical Therapy in the Management of Cerebral Palsy. In addition to identifying postural control as a promising outcome
of physical therapy, she also called for the development of clinically useful measurement tools which not only measure posture but also the resultant effects of improved postural control on functional performance. The lack of clinically feasible, reliable and valid tools for measuring many of the seating outcomes hampers efforts to resolve persisting controversies and evaluate the effectiveness of emerging seating technologies. Although a number of seating measures have been developed, none meet all three criteria.

Significance of the Study

Construction of a measure of postural control which is sensitive to the outcomes of adaptive seating is important for several reasons. First, the measure will assist therapists in the selection of seating interventions for individual children by providing a means of evaluating each of the simulated seating options. Second, such a measure will provide a standard method of documenting changes in postural control which may facilitate communication between therapists and between clinics. Third, an outcome measure will be available to assist in answering research questions regarding the "enhance/restrict" controversy, the timing of seating intervention, and the relative effectiveness of a range of seating options for specific populations. Finally, an evaluative seating measure will provide a means of collecting outcome data for seating clinic program evaluation and quality assurance activities.

The Seated Postural Control Measure (SPCM) is a 34 item, criterion-referenced evaluative measure which is under development at Sunny Hill Health Centre for the purpose of seating outcome evaluation. Item analysis is an important step in the construction of a test of this type. Because a test is only as good as the items of which it is comprised, much attention in the test development process is focused on the design of optimal test items. Retention of test items is contingent upon the demonstration of appropriate psychometric properties which are assessed using item analysis procedures. Subsequent grouping of items into subscales is accomplished through deductive reasoning and then verified by statistical analysis of the association of items and subscales. Information gained from this study will indicate whether further refinements of the
SPCM are required prior to proceeding to the next step of conducting a full responsiveness validation study.

**Statement of the Research Purpose**

Construction of a criterion-referenced test is a multi-step process which involves specification of the test purpose and content domains, item generation, item analysis, item selection, reliability estimation and validation of score use. The purpose of this study was to analyze the item and subscale properties of the SPCM to determine: 1) whether item function is consistent with the purpose of the measure; and, 2) whether the items are appropriately placed in the theoretically-derived subscales.
Definitions

Throughout the proposal, the following terms are used as defined in this section:

Adaptive seating - the custom prescription and application of sitting support devices based on therapeutic principles.

Item analysis - the focused examination of test item properties using techniques of judgmental review and/or statistical review.

Judgmental review - a type of item analysis involving the subjective judgment of the congruence of the items to predefined specifications.

Statistical review - a type of item analysis involving the mathematical analysis of predefined item properties.

Item difficulty - an item property which is calculated as the proportion of examinees who responded correctly to a dichotomous item or the mean of a multi-point item.

Item discrimination - the capacity of an item to discriminate between criterion groups.

Item homogeneity - the degree to which variance is shared between item scores.

Item-subscale congruence - the degree to which the item score correlates with the subscale to which it has been assigned.

Responsiveness - the capacity of a test or item to detect clinically significant change when it occurs.
CHAPTER II LITERATURE REVIEW

Seating Measures Available

Measurements requiring complex instrumentation such as force platforms, electromyography, and motion analysis systems are not appropriate for routine clinical use in the natural settings where therapeutic services are increasingly being delivered. Conversely, clinical measures which have not been standardized may have some value for individual client decision-making but are not useful in evaluating outcomes across clients, therapists, or settings.

Although a number of seating measures exist, none adequately address the issues related to evaluating clinically important change in postural control as a result of seating intervention. In reviewing the standardized clinical seating measures which are currently available, Kirshner and Guyatt's (1985) framework for assessing health indices was utilized. They classified health indices based on the three purposes of discrimination, prediction, and evaluation. A discriminative index is one which distinguishes between individuals on an underlying characteristic. One seating measure which has been developed for this purpose is the Level of Sitting Ability Scale consisting of seven developmental sitting levels defined by the ease of placement in sitting and sitting stability (Mulcahy et al., 1988). Definitions of scale levels were subsequently refined and inter-rater and test-retest reliability established (Fife et al., 1991).

Another type of index, the predictive index forecasts, future health status or performance based on current test scores. Seating scales which attempt to assign risk scores for pressure sore development fit into this category. Pressure sore risk scales assign risk scores to factors which are known to be associated with an increased incidence of pressure sore development. Factors such as age, incontinence, duration of paralysis, smoking, use of anticoagulants, previous fractures, and previous skin breakdown are items frequently included on these risk scales (Crenshaw & Vistnes, 1989).

An evaluative index measures the degree of change on an underlying characteristic over time or as a result of treatment. Several research groups have attempted to develop seating
measures for this purpose. These evaluative measures are examined here in greater depth because it is for this purpose that the SPCM is being developed. The first such measure, an observational scale, was designed to rate changes in sitting stability, upper limb function, visual tracking and alertness when using adaptive seating devices (Hulme, Gallacher, Walsh, Niesen, & Waldron, 1987). Inter-rater reliability was partially established for use of the instrument in a specific research project however, neither test-retest reliability nor evidence of instrument validity have yet been reported for this evaluative scale. No analysis of psychometric properties at the item or subscale levels was reported.

A second evaluative measure, the Sitting Assessment Scale (SAS) consists of five items measuring control of the head, trunk, foot, arm, and hand which are scored from video tape (Myhr & von Wendt, 1991). This test is clinically feasible to administer since video equipment is readily available and portable, allowing use in a number of settings. However, sensitivity of the measure to clinically important change may be compromised by the limited number of test items. Inter-rater and intra-rater reliability have been reported for a small number of children (N = 12) in two different sitting positions (Myhr, von Wendt, & Sandberg, 1993). The Spearman rank correlation coefficient was used to judge item reliability but this coefficient is not the most appropriate means of estimating rater reliability as will be discussed in the subsequent study. Evidence of test-retest reliability and validity for a specified purpose have not yet been provided for this instrument.

A third evaluative measure, the Sitting Assessment for Children with Neuromotor Dysfunction (SACND), is designed to measure the quality of seated postural control for children whose cognitive and motor function is at or above the two year developmental level (Reid, 1993). SACND items are grouped into subscales measuring proximal stability, postural tone, postural alignment, and balance. Test items are administered in both a rest position and during a reaching activity. This test is clinically feasible to use, providing standardized instructions for scoring motor behaviors which are routinely assessed by therapists.

The psychometric properties of the instrument are just beginning to be tested. Current reports of instrument reliability are difficult to interpret for several reasons. First, Reid (1993)
reported internal consistency estimates (Cronbach's alpha coefficients of 0.42 to 0.78) for the test subscales, indicating that internal consistency was deemed to be a requirement of the test. However, according to Kirshner and Guyatt (1985), internal consistency is not an anticipated nor necessary feature of an evaluative measure although it is an important feature of a discriminative measure. It is not clear, therefore, whether Reid intended the test to be both discriminative and evaluative. For an evaluative measure, stability is the essential aspect of reliability which must be demonstrated through examination of test-retest reliability.

The second weakness in Reid's (1993) reliability report was her identification of repeat scoring of videotapes by the same raters as test-retest reliability. Rescoring the same test of the same child is a means of determining intra-rater reliability, not test-retest reliability. Furthermore, Reid's (1993) use of the Pearson product-moment correlation coefficient in the SACND studies of intra-rater and inter-rater reliability did not provide information on rater agreement but rather measured covariation or association of subscale scores (Crocker & Algina, 1986).

This selection of a less than optimal coefficient was also a limitation of the reliability report of Myhr et al. (1993). Systematic differences in scores between raters or within raters over two points in time could be highly correlated but not in agreement. Ottenbacher and Tomchek (1993) noted use of the Pearson coefficient as a common error in reliability studies reported in the American Journal of Occupational Therapy and in Physical Therapy during a five-year review period commencing in 1987. They concluded that the intraclass correlation coefficient was the preferred procedure for measuring these forms of reliability since it provides both association and agreement estimates when used correctly. Reid (1995) used more appropriate statistical procedures to assess an aspect of item reliability (inter-rater reliability) in a subsequent report of percent agreements and Kappa coefficients for a small number of children (N = 8) assessed by three raters. Reid concluded that further reliability studies were required, using larger samples, and test-retest reliability had to be demonstrated before the instrument could be used to assess change.

Preliminary assessment of validity has however been undertaken for the SACND. Content validity was assessed by determining the degree to which 13 expert reviewers agreed that the items met
predetermined specifications (Reid, 1995). The preset criterion level of 65% was surpassed for all items. Initial concurrent validity testing of the SACND involved examining the relationship of its scores with those of the SAS for six children using two types of seating surfaces. Correlations were greater for the saddle seat condition (0.86) than the bench seat condition (0.74) (Reid, 1994). The validity evidence provided is difficult to interpret at this stage because sufficient evidence of reliability has not yet been reported for either the SACND (Reid, 1993) or the SAS (Myhr et al., 1993).

Construct validity was also examined in this study by testing the hypothesis that SACND scores would be higher for rest items in the saddle seat condition (Reid, 1995). The paired t-test result was reported as highly significant (t = 4.43, p = 0.007). A second construct validity study involved visual inspection of item data from the reliability study to determine whether the postulated difference in static and dynamic sitting was detected (Reid, 1995). The expected differences in item scores on these two sitting tasks were not observed.

None of the sitting measures reviewed have sufficiently demonstrated the reliability and validity requirements of an evaluative measure. Nor have the reported measures been subjected to an in-depth statistical analysis of item properties to augment the judgmental review conducted by test developers and expert panels.

Development of the SPCM to Date

Theory and Supportive Rationale

In 1990, prior to the reported development of the SAS and SACND, a team of researchers and seating specialists at Sunny Hill Health Centre recognized a need to evaluate outcomes of seating interventions. Since numerous seating outcomes were identified through literature review and clinical practice, the task of identifying or developing instruments to measure these outcomes was subdivided and sequenced as part of a long-term research plan. The first outcome addressed was the short-term outcome of improved seated postural control. Because no standardized,
clinically feasible instruments existed for measuring anticipated changes in seated postural control as a result of adaptive seating, in children of all levels of severity of their neuromotor condition, instrument development was undertaken. The first step in this process was selection of the conceptual models which would form the foundation for test construction. The importance of explicating the theories underlying our treatments and measurement instruments is important to the development of knowledge within the rehabilitation disciplines (Haley, 1994; Keith & Lipsey, 1993; Reed, 1984; Rothstein, 1985; Tammivaara & Shepard, 1990).

Postural Control Theory

Current concepts of motor control provided the basis for instrument design. The prevailing view of the function of postural control is the integration of movements into coordinated action sequences to achieve a task goal (Reed, 1989). According to dynamical systems theory, postural control is an emergent property which is determined by the interaction of numerous subsystems (Heriza & Sweeney, 1994; Kamm, Thelen & Jensen, 1990). Although some controversy exists regarding the range of subsystems which are involved, there is general agreement that the neurological system, the musculoskeletal system, the sensory system, the environmental context, and the task demands are important contributors to postural control (Heriza, 1991; Horak, 1991; Woollacott & Shumway-Cook, 1990).

Of particular significance to adaptive seating intervention are the biomechanical factors which influence the musculoskeletal system. Three such factors are the starting conditions of the movement, the degrees of freedom of movement, and the limits of movement available. The starting conditions are the alignment of body segments relative to each other, the alignment of body segments relative to the line of gravity and the combination of body segments which are constrained and those which are free to move. The constraints may be internal, such as muscle length, or external, such as a chair back. Postural control strategies used to perform an activity will be different if the starting position of the body changes. For example, when sitting with the feet unsupported and attempting to reach for an object, knee flexors may contract first to stabilize
the calves against the legs of the chair before leaning forward to reach. However, if the legs are supported on a footrest, trunk flexors may contract first and an entirely different sequence of muscle activation occurs.

Adaptive seating is thought to influence postural control by affecting the starting conditions of the movement and by controlling the degrees of freedom and limits of movement. Selective support of body segments is provided through the use of specific seating system components (Tredwell & Roxborough, 1991; Trefler, 1984; Ward, 1994). Re-orientation of the body, relative to the line of gravity, is achieved through adjusting the orientation of the entire seating system (Trefler, 1984; Ward, 1994). It is hypothesized that optimizing these starting conditions for movement and limiting the range of movement to that which is controllable by the individual will enhance functional movement capacity.

Based on postural control theory, the seated postural control outcomes to be measured with the SPCM were thus conceptualized in two domains. These domains were postural alignment and functional movement.

An additional aspect of systems theory which was considered when generating items within the functional movement domain was the important effect of the task goal on movement performance. All motor actions involve a cognitive-perceptual component (Montgomery, 1991). For example, the feedforward command will call for greater or smaller effort depending on the demands of a specific task. As well, the context of the task and motivational factors affect performance (Lewthwaite, 1990). Hence the grading and selection of items for the functional movement domain was based on goal-directed actions that were significant in everyday function rather than requests for movements without a purpose meaningful to the child. Items were therefore developed which measured the effects of alignment changes on functional movements with varying task demands.
Measurement Framework

In addition to the selection of a conceptual framework of the postural control system, selection of a measurement framework was a prerequisite to test development. Important measurement issues considered in developing and using a measure were the level of measurement and the purpose of the measure.

Level of measurement

Several authors have stressed the importance of conceptualizing the levels of the human system at which our interventions are being directed (Guccione, 1991; Kielhofner, 1985) and ensuring that our measurement tools are valid for assessing the level of the system of interest (Campbell, 1991; Haley 1992). Campbell (1992) and Haley (1992) have both proposed measurement frameworks for assessing motor performance based on the World Health Organization's (WHO) classification of impairment, disability and handicap (World Health Organization, 1980). In applying the WHO classification to motor performance, impairment refers to the abnormality or loss of a motor component or process, disability refers to the restriction of functional activity and handicap refers to the inability to perform a social role due to the motor impairments or disabilities (Haley, 1992). Campbell (1991) recommended the use of Nagi’s (1969) model to develop a measurement framework for children; this model adds a functional limitations category between the impairment and disabilities categories. Haley (1992) recently proposed further elaboration of this model to include developmental and contextual dimensions as well as measurement constructs. His measurement construct associated with the functional limitations classification is the capacity to demonstrate discrete functional "skills" (usually tested within a clinical context). The measurement construct associated with the disability classification is the performance of functional "activities" (within a natural context) and that associated with the handicap classification is the performance of social, family, and personal "roles".

Utilizing Haley's expanded model, the SPCM can be considered to measure seating outcomes at both the impairment and functional limitation levels. The alignment section, which measures changes in alignment of body segments, evaluates abnormalities in a postural control
component which could be considered the impairment level. The functional movement section of the SPCM assesses the capacity to achieve a specific task in the clinical setting and is thus measuring functional limitations as described in the Haley (1992) model.

**Purpose of measurement**

The purpose of the SPCM is to evaluate clinically significant changes in postural control resulting from adaptive seating intervention. Within Kirshner and Guyatt's (1985) purpose-based measurement classification scheme, the SPCM is thus considered an evaluative measure. The measurement properties of an evaluative test are distinctly different from those whose purpose is discrimination or prediction.

An evaluative index measures the degree of change of an underlying characteristic over time or as a result of treatment. A significant validity requirement of an evaluative test is the capacity to detect clinically significant change. Kirshner and Guyatt (1985), labeling this capacity responsiveness, have identified it as a necessary characteristic of evaluative tests which is not a requirement of tests whose primary purpose is discrimination or prediction.

A number of key considerations for developing an evaluative measure have been described by Kirshner and Guyatt (1985) and expanded upon by the developers of the Gross Motor Function Measure (Russell et al., 1993):

1) Items must be selected for their responsiveness (i.e., their capacity to detect clinically important change)

2) Item scaling must incorporate sufficient gradations to register change

3) A sufficient range of items is required to detect all clinically important treatment effects

4) The stability of the measure must be demonstrated to show that scores of children who are not changing do not vary significantly on repeated testing (small within-subject variation)

5) Validation of the responsiveness of the measure requires demonstrating that it is capable of detecting clinically important change when it does occur and is stable in the absence of change
Test Development

Initial development of the SPCM took place over a three year period (1990-1993) at Sunny Hill Health Centre for Children through a grant funded by the British Columbia Medical Services Foundation. The research team, lead by Susan Fife, proceeded systematically through the stages of criterion-referenced test construction up to the point of producing a pilot version of the SPCM and conducting two reliability studies (Fife et al., 1991; Fife et al., 1993a). Test construction involved selection of the theoretical framework, circumscribing the test content domain, defining item specifications (Appendix 1), developing items based on defined specifications, and judgmental review of content validity.

The refined pilot version of the SPCM, which can be administered in 30 minutes or less, consists of 22 alignment items and 12 functional movement items (Appendix 2). Items were generated through review of existing measurement tools and the contribution of local seating specialists. Seven external North American seating experts reviewed the items for clinical feasibility, necessity, sufficiency, and their opinion of face validity.

In the alignment section, graphic representations and written descriptions of postures are used to facilitate administration of the test items. A neutral position of each body segment in the sitting position is defined and increasing angular deviations from the neutral position represent mild, moderate and severe degrees of abnormal alignment. A four-point ordinal scale is used to score each segmental posture. Scale increments were selected to be as sensitive as possible to detect changes in alignment yet also be able to be reliably scored. Operationalizing clinicians' definitions of their routinely used categories of normal to severe alignment problems seemed the best compromise between attempting to achieve scale sensitivity and reliability. Visual observation and palpation are the only methods used to estimate postural alignment and therefore items are grouped on the scoring sheet by the rater's view of the individual being tested.

Each of the 12 items in the function section consists of four criterion-referenced levels, with higher grades representing better task achievement (from zero to completion). The items are designed to assess head and trunk control, reaching, grasping, releasing, bimanual manipulation,
and wheelchair mobility. Test administration guidelines were documented (Appendix 2) and scoring sheets developed to standardize administration procedures.

Inter-rater and test-retest reliability of pilot versions of the SPCM were assessed in two studies (Fife et al., 1991; Fife et al., 1993a). Because data from the reliability studies will be used in the proposed study, these reliability studies will be described in greater detail in a subsequent section.

The next step in test development is to analyze the properties of individual items to determine whether they are functioning as intended within the test. Berk (1984) described two types of item analysis which are used to ascertain the degree of item validity for criterion-referenced tests. The first type of item analysis, termed judgmental review, is the subjective judgment of the congruence of the items to the predefined specifications and to the content domain. Statistical review is the mathematical analysis of relevant item properties. Statistical item analysis does not replace, but rather augments judgmental review (Berk, 1984).

This study will involve the statistical analysis of item properties to augment the judgmental review conducted by test developers and the external expert panel. Prior judgmental review of the SPCM determined that the items were perceived to match the predefined item specifications and as such: 1) were congruent with the defined content and subscale domains; 2) were worded in a way which was not ambiguous; 3) had the capacity to detect changes in postural control which were thought to result from adaptive seating intervention; 3) were feasible to administer in a clinical setting; 4) were necessary for testing the content domain, and; 5) were sufficient in range to adequately assess the domain. Statistical item analysis is now required to check for item redundancy; to begin to examine the responsiveness of the items; and, to assess the degree of association between each item and the subscale to which it has been logically assigned.

Item Analysis Methods

A major goal of evaluative test construction is to create a test of minimum length that will produce scores with the necessary degree of reliability, validity, and responsiveness. The
importance of item analysis in the test construction process has been stressed for both norm-referenced and criterion-referenced tests (Berk, 1984; Crocker & Algina, 1986; Gwyer, 1989). The measurement properties of the finished test are essentially a function of the characteristics of the items comprising the test. Item analysis is the term used to describe the examination of the properties of examinees' responses to individual test items. The term may be used selectively to indicate the statistical analysis of item properties (Crocker & Algina, 1986) or more broadly to indicate both the statistical and judgmental analysis of item properties (Berk, 1984; Haladyna & Roid, 1981). The use of both judgmental and statistical methods is essential to the comprehensive analysis of item characteristics (Berk, 1984).

Item analysis takes place to varying degrees at the judgmental and statistical levels throughout the test development process. Judgmental review is used initially to examine items from existing tests for potential inclusion in the item pool. Judgmental and statistical review are used for item pool reduction. Judgmental review is again used to assign items to subscales and statistical review is subsequently undertaken to validate the subscale assignment. Statistical analysis is later conducted to identify items which are not functioning as intended and judgmental review is then used to determine whether to eliminate or revise faulty items.

Item properties which are frequently examined are item homogeneity, item-subscale congruence, item difficulty, item discrimination/sensitivity and item reliability.

**Item Homogeneity**

Item homogeneity is the degree to which score variance is shared amongst items and is measured using the correlation coefficient. Homogeneity is an item property which, if present for a pair of items, indicates that the items of the scale are measuring the same underlying trait. Ideally, low to moderate correlations are found amongst items, indicating that all are converging in measuring a unifying trait. However, correlations which are high may indicate that one of the item pairs is redundant and thus not contributing unique information, adversely affecting content validity (Streiner and Norman, 1989). This negative affect on content validity results from the over-emphasis of a particular content area by inadvertently including redundant items within a test.
Examination of inter-item correlations for the SPCM will reveal whether any items are redundant and thus could be eliminated from the test, decreasing test length. Inter-item correlations greater than or equal to .95 could be considered redundant because each item is contributing little unique information. The Spearman rank correlation coefficient will be used to examine inter-item correlations because of its suitability for ordinal level data (Glass & Hopkins, 1984).

**Item-subscale Congruence**

Item-subscale congruence is the degree to which the item score correlates with the subscale to which it has been assigned. When summing scores comprising a subscale, it is assumed that each item adds something to the others in the measurement of an underlying characteristic, otherwise it would not make sense to calculate a summed subscale score (Nunnally, 1967). Streiner and Norman (1989) recommended assessing this feature by correlating the item with the subscale score omitting that item. They also described the Pearson product-moment correlation coefficient as the most appropriate statistical procedure for scales with more than two response options. In suggesting this correlation coefficient, the level of the data was not mentioned and it is thus presumed that the reference was to interval or ratio level data. When at least one of the variables being compared is ordinal level, the Spearman rank correlation coefficient is frequently recommended (Glass and Hopkins, 1984; Gilbert, 1976).

Item-subscale correlations are anticipated to be higher (> .2) within scales than across scales (Streiner and Norman, 1989). Examination of item-subscale correlations for the SPCM will determine whether there is statistical support for the subscale structure of the test. Findings of higher within subscale correlations than between subscale correlations will lend support to the selected subscale structure while lower within than between subscale correlations will indicate a lack of statistical support for the subscale structure.
Item Difficulty

A third item analysis index, item difficulty, is defined for dichotomous items as the proportion of examinees who answered the item correctly (Crocker and Algina, 1986). For multi-category items, item difficulty is the mean response. This index is used to determine whether individual items are too easy or too difficult and thus may not be adequately testing the objective for which they were designed. For example, if the difficulty index for a particular evaluative test item is very high (i.e., all examinees achieved high item scores) on a pretest, it may be an indication that either the objective or the item is flawed. A low difficulty index (i.e., all examinees achieved low item scores) may be an indication that the item is ambiguous and thus no one is able to score highly; or, the objective which the item was designed to measure was not being achieved with the intervention. Comparison of the item difficulty index to the mean or median difficulty index for a group of items which were designed to measure the same objective also provides information on relative item functioning (Crocker & Algina, 1986). Analysis of SPCM item difficulty will assist in determining which items have the capacity to show change post-intervention. If an item is found to have a very high difficulty index pre-intervention (≥ 3.5 for multipoint items and ≥ 3.83 for two-point items), the item will be reviewed for adherence to item specifications, particularly those relating to item responsiveness.

Item Discrimination

A fourth item analysis index, item discrimination, is an indicator of the item's capacity to discriminate between criterion groups. Groups are selected based on the purpose of the test, and all items are administered to both groups. Item scores are then examined to determine whether the items discriminated between the groups as was anticipated. In the educational measurement literature, these groups are usually uninstructed and instructed groups and consequently the discrimination index is referred to as the instructional sensitivity index (Berk, 1984; Crocker & Algina, 1986; Hanson, McMorris & Bailey, 1986). Although numerous item discrimination indices are reported to exist, Berk (1984) described four of the most practical and meaningful. The
simplest discrimination index is the pretest-posttest difference (DIS_{ppd}) which is the difference between the proportion of examinees who responded correctly on the posttest minus the proportion responding correctly on the pretest. This index is sensitive to group performance differences but insensitive to individual performance differences.

A second discrimination index is the uninstructed-instructed (or competent-incompetent) group difference (DIS_{UGD}) which is the proportion of examinees in the instructed group who responded correctly minus the corresponding proportion in the uninstructed group. Because calculation of this index does not use the same examinees in both groups, a waiting period for instruction is not required. Disadvantages are the dependence on the similarity of groups and again the lack of detection of individual performance changes. This index was used to examine item discrimination properties of the DeGangi-Berk Test of Sensory Integration (Berk & DeGangi, 1983). Items were administered to two groups which consisted of 38 children who had a developmental delay and 101 children who were developing normally. Each of the ordinal items was totaled across examinees for each group and item means were calculated. The discrimination index was derived by subtracting the mean of the delayed group from the nondelayed group and testing for significance using the t-test. Thirty-seven of the original 73 items were eliminated from the test because they failed to discriminate between the two groups. Assessment of the magnitude of the discrimination index was reported using Cohen's (1977) formulae 2.2.1 and 2.3.2 for estimating effect size. The effect size was classified as small if 0.2 to 0.5, medium if 0.5 to 0.8, and large if greater than 0.8.

A third discrimination index, the individual gain (DIS_{IG}), is the proportion of examinees who responded incorrectly on the pretest and correctly on the posttest. This index detects individual performance gains but does not account for unchanged or deteriorating performance. The final discrimination index described by Berk (1984) is the net gain (DIS_{NG}). This index is the DIS_{IG} minus the proportion of examinees who responded incorrectly on both the pretest and the posttest. This index takes into account all examinees whose score could have improved on the posttest and is thus a more conservative estimate of the instructional sensitivity of the item.
A somewhat similar item sensitivity characteristic is described in the health measurement literature. This characteristic, labeled item responsiveness, is the capacity of the item to detect clinically important change when it occurs (Kirshner & Guyatt, 1985). Test responsiveness has been assessed by comparing scores to a test of known responsiveness (Meenan et al., 1984), examining pre- and post-intervention scores using a treatment of known effectiveness (Guyatt, Walter & Norman, 1987), or building responsiveness evidence through a priori hypothesis testing (Rosenbaum et al., 1990). These methods of assessing test responsiveness could also be applied to the assessment of item responsiveness.

For SPCM items, the capacity to detect individual changes in postural control as a result of adaptive seating intervention is the item characteristic which is associated with the discrimination or sensitivity index. Because within-subject changes are of greatest interest, use of one of the sensitivity indices which quantify individual gain ($\text{DIS}_{IG}$ and $\text{DIS}_{NG}$) seems the most appropriate for preliminary examination of SPCM item sensitivity. The $\text{DIS}_{IG}$ is selected because it provides an initial indication of item sensitivity based on the proportion of participants whose scores improved. Interpretation of the $\text{DIS}_{IG}$ is further supplemented by the item difficulty index which indicates whether the item scores had the capacity to change.

Ideally, the discrimination index would be calculated using pre- and posttest scores of participants receiving a treatment of known effectiveness. Unfortunately, the effectiveness of adaptive seating is not yet known due to the lack of available measurement tools. However, considering the SPCM has been specifically designed to measure the outcomes of adaptive seating, these outcomes are presumed to exist and it thus seems reasonable to test item sensitivity on a treatment of presumed efficacy (i.e., adaptive seating) for which the test has been developed. Examining item scores of children tested under two conditions "with" and "without" their adaptive seats and calculating the discrimination index provides an initial indication of potential item sensitivity. Because the true effectiveness of adaptive seating is not known, the discrimination index can only be used to determine whether SPCM scores change in the anticipated direction following seating intervention. If positive score changes are detected, as indicated by a high
discrimination index, some support is provided for item sensitivity. On the other hand, if positive score changes are not detected, it is not possible to determine whether the low discrimination index resulted from an ineffective intervention or an insensitive item.

To supplement the interpretation of the DISIG, the proportion of participants whose scores decreased from the 'without' to the 'with' seat condition must also be determined. A similar proportion of subjects whose scores decreased as increased may be a reflection of low reliability of some of the items resulting in chance score increases and decreases. A higher proportion of subjects whose scores decreased could be an indication that the item may be responsive but the change is not in the anticipated direction. A substantially higher proportion of subjects whose scores increased than decreased may indicate that the items are functioning as anticipated and thus may have the potential to be responsive.

**Item Reliability**

Reliability is defined as the degree to which a measurement is free from error and is described as consistency or reproducibility (Task Force on Standards of Measurement in Physical Therapy, 1991). The type of reliability of interest is predicated by the purpose for which a test is being designed. For an evaluative test, demonstration of consistency of within-subject scores over time must be demonstrated (Kirshner & Guyatt, 1985). Consistency of between-rater scores at one point in time must also be demonstrated if more than one rater will be administering the test (Streiner & Norman, 1989). Item reliability for an evaluative test is assessed by examining the inter-rater and test-retest reliability at the item level. Reliability of SPCM items was examined in two studies which were designed to measure both inter-rater reliability and test-retest reliability. The first study examined reliability in two seated conditions using two raters (Fife et al., 1991). Items were modified slightly in the second study which examined test-retest and inter-rater reliability using only the 'with' seat condition and two raters (Fife et al., 1993a).
Synthesis of Item Analysis Results

Numerous approaches to statistical analysis of item functioning are evident in the test construction literature. Although most authors agree that items should be analyzed in relation to the purpose for which the test is being designed (Ghiselli, Campbell & Zedeck, 1981; Kirshner & Guyatt, 1985; Nunnally, 1983; Streiner & Norman, 1989) there is a divergence in views on the use of some item properties for item retention decisions. Berk (1984) assigned precedence to judgmental review of item-objective congruence and secondarily to statistical review of item difficulty and item discrimination. For an evaluative test, Kirshner and Guyatt (1985) emphasized item responsiveness and reliability as key features in the analysis of item functioning. Both groups suggested using the instructional sensitivity index as a responsiveness index for item selection decisions.

Nunnally (1983) however recommended against basing test construction for evaluation research on empirical evidence of the amount of change. He contended that the use of item difficulty or pretest/posttest changes for item selection would result in a test comprised of heterogeneous items for which a total score would be uninterpretable. Instead, Nunnally (1983) suggested constructing tests which are homogeneous in content so that they could be interpreted in relation to an underlying attribute. He thus suggested retaining items which contributed to the internal consistency of the test.

This difference in priorization of features is possibly due to a difference in measurement goals. Those who advocate selection of items based on their demonstrated capacity to detect change, seem to have a primary measurement goal of assessing treatment effectiveness and are thus interested in measuring all possible treatment outcomes, not just those outcomes confined to one attribute or construct. Those researchers who advocate selection of items based on internal consistency would appear to have a primary measurement goal of assessing how a particular human attribute is effected by the treatment and are thus not interested in items measuring different attributes or outcomes. The SPCM is being constructed to measure one particular attribute,
postural control, but is also intended to measure only those aspects of postural control which are thought to change as a result of adaptive seating intervention. Thus homogeneity (at both the item and subscale level), item difficulty, item responsiveness, and item reliability are all features which will be considered in judging item functioning.

**SPCM Reliability Studies**

The item analysis was conducted using the data from the two reliability studies which were undertaken to assess the inter-rater and test-retest reliability of the SPCM. The research team who conducted these studies in 1991 and 1993 at Sunny Hill Health Centre was led by Fife (Fife et al., 1991; Fife et al., 1993a).

**Participants**

For the first study, a convenience sample of 45 children was selected from the registry of children who had attended the Seating Clinic at Sunny Hill Health Centre in the previous five years. Inclusion criteria consisted of: 1) age between birth and 19 years; 2) residence in the Lower Mainland; 3) use of an adaptive seating system; and, 4) informed consent. The one exclusion criterion was planned surgical intervention in the data collection period. Of the 45 children who met the criteria, four were used for rater training and one was unable to attend the second test session. Five children were thus excluded from the later data analysis. Participants' mean age was 9.06 years, with a range of 1.67 to 18.5 years.

A convenience sample of 51 individuals meeting the same inclusion criteria (except age, which was expanded to 28 years) was selected for the second reliability study. One of the recruited children was not able to attend the second test session and was therefore excluded from the data analysis. Participants ranged in age from 1.3 to 27.9 years, with a mean age of 11.9 years.
Raters

Two raters, each with at least five years of pediatric experience and two years of adaptive seating prescription experience, participated in the studies. In the first study, one rater was an occupational therapist and the other was a physiotherapist. In the second study, the same occupational therapist participated and the second rater was a combined occupational/physiotherapist. Rater training consisted of study of the SPCM Administration Guidelines, informal item administration in daily clinical practice, and supervised conduct of study procedures on four pilot study children.

Materials

Three assessments were used in the studies: the Change Questionnaire, the Level of Sitting Scale, and the SPCM. The Change Questionnaire, developed for the reliability studies, consisted of a number of Likert scale items intended to estimate whether the child's postural control had changed from one assessment session to the next. Although subjects selected for the study were not expected to change during the data collection period, the possibility of unexpected change due to illness or medical intervention could not be overlooked. The Level of Sitting Scale was developed during the SPCM construction process to serve as a global sitting ability measure which could be used to describe participants. It was included for this purpose on the face sheet of the SPCM record form. The Level of Sitting Scale was a modification of the Level of Sitting Ability Scale developed by Mulcahy and colleagues (Mulcahy et al., 1988).

The pilot versions of the SPCM varied somewhat between the two studies. Although the item content was the same (22 alignment items and 12 function items) the alignment scales were modified from the first to the second study and additional visual aids were used to administer many of the alignment items in the second study. The ordinal scale was reversed for the second study so that higher scores represented greater angular deviations. In the first study, a score of 3 indicated normal alignment while a score of 0 represented the greatest alignment deviation. This reversal of scale order was done to assist future test users in interpreting subscale scores as the magnitude of
summed alignment deviations. Another change in alignment item scaling involved changing the width of certain alignment score categories and recording alignment angle ranges on the form rather than the midpoints of angles in each category. Additions were also made to the alignment item administration guidelines to include the use of a flexible ruler as a visual aid for items using the pelvis as a reference point, and to include the use of a large protractor for angle estimation. These latter changes were made in an attempt to increase the reliability of item scoring. The function section items remained the same for both studies. The SPCM form and administration guidelines (draft #4) used in the 1991 study are found in Appendix 2 and 3. Corresponding forms used in the 1993 study (draft # 8) are located in Appendix 4 and 5.

**Study Design and Procedures**

Repeated measures designs were used for both reliability studies. In the first study, the effects of three variables on SPCM scores were examined. The variables were raters, seating condition, and occasion. Both raters assessed all the children under two seating conditions on two occasions. The two seating conditions were; 1) a 'with' seat condition in which the child was seated in their own adaptive seat; and, 2) a 'without' seat condition during which each child was seated in a standard, minimally supportive Tumbleform Feeder seat. The order of raters and the order of seating conditions were alternated to avoid an order effect. Children were assessed on two occasions three weeks apart. This interval was deemed to be sufficiently short to avoid maturational effects but sufficiently long to allow raters to forget childrens' previous scores.

In the second reliability study, two factors (rater and occasion) were examined. All participants were assessed by both raters on two occasions which were again scheduled three weeks apart. In both studies, the LSS was administered by both raters on each occasion and the change questionnaire was completed by the caregiver on both occasions.
Data Analysis

In the first study (Fife et al., 1991) interrater and test-retest reliability were examined using agreement tables. Indexes of estimated item reliability utilized were the percentage of agreement (number of agreements/total observations x 100) and the Kappa statistic which accounts for chance agreements (Fleiss, 1980; Haley & Osberg, 1989). Haley and colleagues (Haley, Harris, Tada & Swanson, 1986) interpreted Kappa values as: poor, if less than 0.40; fair, if 0.40 to 0.74; and excellent, if 0.75 or higher when assessing item reliability of the Movement Assessment of Infants (Chandler, Andrews & Swanson, 1980). For analysis of the SPCM item reliability, a Kappa value of 0.40 was thus set as the minimum acceptable level. Reliability of alignment and function section scores was determined using the intraclass correlation coefficient (Fife, 1992).

In the second study (Fife et al., 1993a), item reliability was assessed by the unweighted (K) and weighted Kappa (Kw) statistics. The Cicchetti method (Fleiss, 1980) was used to assign weights to discrepancies in item scores between raters and between tests. Reliability of the alignment subscales and alignment and function section scores was estimated using intra-class correlation coefficients (ICC 3,1) as described by Shrout and Fleiss (1979).

Results and Conclusions

In the first study (Fife et al., 1991) the mean inter-rater Kappa coefficient across the two seated conditions and the two test sessions was 0.45 for the alignment items and 0.85 for the function items. Within these four data sets, Kappa values less than the acceptable level of 0.40 were obtained for 6 to 12 of the 22 alignment items and one of the 12 function items. Results were even less satisfactory for test-retest reliability. Across the two seated conditions and the two raters, the mean test-retest Kappa coefficient was 0.35 for alignment items and 0.29 for function items. Within the four data sets, Kappa values under the acceptable level were obtained for 11 to 15 of the possible 22 alignment items and 8 to 10 of the possible 12 function items. Estimates of inter-rater and test-retest reliability of the total section scores using the ICC were > 0.80 for alignment and > 0.90 for function (Fife 1992).
In the second study (Fife et al., 1993a) mean inter-rater weighted Kappa coefficients were 0.67 for alignment items and 0.83 for function items. Mean test-retest weighted Kappa coefficients were 0.59 for alignment items and 0.77 for function items. All alignment item weighted Kappa coefficients were above 0.40 with the exception of inter-rater reliability of the trunk rotation item (Kw = 0.34) and test-retest reliability of shoulder height (Kw = 0.30) and head lateral tilt (Kw = 0.38). All weighted Kappa coefficients for function items were above 0.40 except anterior/posterior trunk movement for which Kw could not be calculated due to the limited distribution of scores across categories.

Conclusions of the first study (Fife et al., 1991) were: 1) some alignment items required refining to improve reliability; 2) trends in change scores on re-testing required exploration to determine why reliability was low; 3) methods of assessing rater agreement which gave credit for partial agreement required examination. The second study (Fife et al., 1993a) concluded that the SPCM demonstrated acceptable inter-rater and test-retest reliability at both the item and section score levels.
CHAPTER III METHODOLOGY

Research Hypotheses

The following research hypotheses have been developed based on the research questions and a review of the literature describing methods of item and subscale analysis:

Hypothesis 1: Inter-item correlations will be less than or equal to 0.95.

Hypothesis 2: The item difficulty index in the pre-seating condition will be less than or equal to 3.50 for multi-point items and less than or equal to 3.83 for limb items with only two score levels.

Hypothesis 3: The item discrimination index, individual gain ($\text{DIS}_{\text{IG}}$), will be greater than or equal to 0.2.

Hypothesis 4: The SPCM item scores will be more highly correlated with subsection scores to which the item is assigned than to other SPCM subsection scores.

Hypothesis 5: SPCM alignment subsection scores will be more highly correlated with the alignment section score than with the function section score.

Participants

The sample for this study consisted of the children who participated in the two SPCM reliability studies (Fife et al., 1991; Fife et al., 1993a). As previously reported, for the 1991 study, a convenience sample of 45 children was selected from the registry of children who had attended the Seating Clinic at Sunny Hill in the previous five years. Inclusion criteria consisted of:

1) age between birth and 19 years; 2) residence in the Lower Mainland; 3) use of an adaptive seating system; and, 4) informed consent. The one exclusion criterion was planned surgical intervention in the data collection period. Of the 45 children who met the criteria, four were used for rater training and were thus excluded from the later data analysis. Participants' mean age was 9.06 years, with a range of 1.67 to 18.5 years. Eight of the 41 participants were not tested under all eight conditions. Three of these children attended only one of the two test sessions; one child
was tested in the 'without seat' condition only; two children were tested on only one occasion in
the 'without seat' condition; and, two children were tested in the 'with seat' condition only.

A convenience sample of 51 individuals meeting the same inclusion criteria (except age,
which was expanded to 28 years) was selected for the 1993 reliability study. One of the recruited
participants was not able to attend the second test session and therefore only two of the four
possible test scores were available. Participants ranged in age from 1.3 to 27.9 years, with a mean
age of 11.9 years. Data from the 1991 study were used to examine hypotheses 2 and 3 because
children were tested in both the 'with' and 'without' seat conditions in this reliability study.
Participant data from the 1993 study were used to examine hypotheses 1, 4 and 5 because SPCM
score reliability was higher in this second study. Descriptive characteristics of participants are
summarized in Table 1.
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Study Design

Although the reliability data were collected as part of two prospective, repeated measures designs, the current study is considered retrospective because the research questions were developed after the data had been collected. Retrospective analysis of differences in SPCM item scores in the 'with' and 'without' seat condition was undertaken to test hypothesis 3. Analysis of the relationship between items and item-subsection scores and between subsection-section scores was undertaken to test hypotheses 1, 4 and 5.

Data Collection

Data for this study were obtained from the data sheets and the computer data bases which were developed for data storage and retrieval in the reliability studies. The completed SPCM data sheets were reviewed to verify the accuracy of the database records. SPCM data, participant descriptors, and LSS data were retrieved from the databases. The SPCM data retrieved was the recoded data which assigned the same series of numbers to the item responses in both reliability studies. For the Alignment items, the recoding assigned a score of 1 to the severe category, 2 to the moderate category, 3 to the mild category and 4 to the normal category. Scores for the Function items did not require recoding because they were scored from 1 to 4 on the original score sheets.

Descriptors of participants in the 1993 study corresponding to descriptors of the 1991 study participants (summarized in Table 1) were extracted from the database.

Data Management and Analysis

The number codes assigned to participants in the reliability studies were retained and participants were identified by number only in the database and data tables. The completed data collection forms and the list of participant names with corresponding number codes from the original studies continue to be stored in a locked cabinet in the Therapy Department research office at Sunny Hill Health Centre.
The data from the 1991 and 1993 reliability studies were imported from Excel into Statview 4.0 (Abacus Concepts, 1992) where the data analysis was conducted. The data were first explored to determine the extent of missing data and to determine how the missing data should be handled.

Analysis of hypothesis 1 required the calculation of correlation coefficients for each of the 561 item pairs using data from the 1993 reliability study. Scatter plots were graphed with one SPCM item score along each axis for each of the four data sets. The scatter plots were examined for linearity, homoscedasticity and sufficient variance to determine whether these assumptions of the correlation coefficients were met. If all assumptions were met, the Spearman rank correlation coefficient was calculated for each item pair in each data set and displayed in a correlation matrix. The mean correlations across all four data sets were calculated for items with at least one correlation greater than 0.90 (so that means would only need to be calculated for those item pairs which might possibly have mean correlations nearing 0.95). Mean correlations were displayed in tabular form and examined to determine whether hypothesis 1 was upheld.

Statistical analysis of hypothesis 2 involved the calculation of the item difficulty index for each of the 34 SPCM items in the pre-seating condition. Data from the Fife et al. (1991) reliability study collected in the 'without' seat condition were used to calculate the difficulty indices. Because item reliability was not sufficiently high for all items across raters and time, item scores could not be combined across data sets. The item difficulty (mean score) for each item was calculated for each of the four data sets and the mean item difficulty then calculated. The mean item difficulty index was examined in relation to the preset levels for multi-point and two-point items to determine whether hypothesis 2 was upheld for each item.

Statistical analysis of data for hypothesis 3 involved the calculation of the discrimination index for each of the 34 SPCM items using data from the 1991 reliability study. The discrimination index was calculated for the multi-point SPCM items by logically extending Berk's formula for dichotomous items. The individual gain discrimination index ($\text{DIS}_{IG}$) was calculated as the proportion of participants whose score increased from the pre-seating to the post-seating condition (extending Berk's formula of the proportion of subjects who responded incorrectly on
the pre-test and correctly on the post-test) for each of the four combinations of rater and occasion. The four discrimination indices for each item were averaged and the mean DIS$_{IG}$ displayed in a table and examined to determine whether each was greater than or equal to 0.2 and thus whether hypothesis 3 was upheld for each item.

To assist in later interpretation of the DIS$_{IG}$, the proportion of subjects whose scores decreased from the pre-seating to the post-seating condition was also calculated for each of the same four combinations of raters and occasions. In addition, the mean proportion of subjects whose scores decreased was calculated for each item and displayed in a table with the mean DIS$_{IG}$. The proportion of subjects whose scores were unchanged from the pre-seating to the post-seating condition was also calculated and the mean displayed in the same table to assist in later interpretation of the results.

Hypotheses 4 and 5 were examined using data from the 1993 reliability study. For hypothesis 4, scatter plots were graphed with SPCM item scores along one axis and subsection scores (with the item score removed) along the other axis for each of the four data sets. The scatter plots were examined for linearity, homoscedasticity and sufficient variance to determine whether these assumptions of the correlation coefficients were met. If all assumptions were met, the Spearman rank correlation coefficient was calculated for each item-subsection combination in each data set. The Spearman correlation coefficient was selected because one of the variables being correlated, the item score, was ordinal level data. The mean correlations across all four data sets were calculated and displayed in a correlation matrix. These mean correlations were then examined to determine whether hypothesis 4 was upheld.

For hypothesis 5, scatter plots were graphed with SPCM subsection scores along one axis and section scores (with the subsection score removed) along the other axis for each of the four data sets. These scatter plots were examined for linearity, homoscedasticity and sufficient variance. If all assumptions of the correlation coefficient were met, the Pearson product-moment correlation coefficient was calculated for each subsection-section score combination in each data set and displayed in a correlation matrix. The Pearson product-moment correlation coefficient was
selected because both the subsection and section scores are composite scores which could thus be treated as interval level data. The mean correlations across all four data sets were calculated and examined to determine whether hypothesis 5 was substantiated.
CHAPTER IV RESULTS

The results of the missing data exploration and data analysis described in Chapter III for each of the research hypotheses are presented in this chapter. The extent of missing data is first reported for each of the reliability studies and strategies for handling missing data in subsequent analyses are then described. Results of the data analysis for each of the five research hypotheses are reported in tabular form with accompanying written summaries.

Missing Data

The conditions under which some of the subjects were not tested are described in the previous chapter in the Participants section. The two databases were further examined to determine the extent of additional missing data. The database from the first reliability study (Fife et al., 1991) had 24 items with missing data. Of a possible 292 scores (8 data sets x 41 subjects - 36 tests) for each item, ten items had only 1 missing score, eight items had two missing scores, two had four missing scores, one had five missing, one had 10 missing and two (F11 and F12) had 27 missing. The database from the second reliability study (Fife et al., 1993a) had 14 items with missing data. Of a possible 202 scores (4 data sets x 51 subjects - 2 tests) for each item, ten items had only one missing score, two items had two missing scores and two items (F11 and F12) had 10 missing scores.

The higher number of missing scores on the latter two items in each database was due to the testers' inability to assign a score for these wheelchair mobility items because the child did not bring their wheelchair to the testing session or they could not be safely positioned in the wheelchair in the 'without seat' condition. Other function item scores were missing for the small number of items which the child could not be persuaded to attempt. The small number of missing alignment scores were mainly a result of the rater's inability to assign a score because the seating components covered the reference points. Other than the wheelchair mobility items, missing item scores were considered to be of sufficiently small number that systematic score omissions were not a concern.
Further exploration of participants with missing wheelchair mobility item scores revealed nine children with missing scores for both F11 and F12 in the first study (Fife et al., 1991) and four participants with both scores missing in the second study (Fife et al., 1993a). No systematic differences in sitting level nor diagnostic group were evident between participants with and without missing data. The two raters and two test occasions were equally represented in the missing data but the two test conditions were not. Twenty-three scores in the first study were missing in the 'without seat' condition while only four scores were missing for F11 and F12 in the 'with seat' condition.

The strategy used to handle missing data was to omit the item with missing data from the calculations rather than attempting to estimate a score for the item. To avoid eliminating other item scores for participants with missing data, analyses requiring the use of a correlation matrix were set up to specify pair-wise deletions rather than list-wise deletions. Specifying pair-wise deletions eliminates the missing item score from the pair only while specifying list-wise deletions eliminates all item scores for that participant from all calculations in the correlation matrix.

**Item Homogeneity**

The four data sets specified for each of two raters on each of two occasions in the second reliability study (Fife et al., 1993a) were used to assess item homogeneity. Scatter plots of the 561 item pairs in each of the four data sets revealed 37 item pairs which did not meet one or more of the assumptions for use of the correlation coefficient; these item pairs were thus excluded from the data analysis. Table 2 lists the excluded pairs.

The Spearman rank correlation coefficient was calculated for each of the remaining 524 item pairs. The mean item correlations were calculated for item-pairs with correlations exceeding 0.90 in at least one of the four data sets to detect those items with high mean correlations. These correlations are displayed in Table 3. Only one of the mean inter-item correlations (F11/F12) exceeded the 0.95 cut-off point for item redundancy, as proposed in hypothesis 1.
### Table 2

**Item-Item Pairs Excluded from the Correlation Matrix**

<table>
<thead>
<tr>
<th>Item Pair</th>
<th>Item Pair</th>
<th>Item Pair</th>
<th>Item Pair</th>
<th>Item Pair</th>
<th>Item Pair</th>
</tr>
</thead>
<tbody>
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<td>F1/F12</td>
<td>F7/A14</td>
<td>F11/A15</td>
<td>A5/A17</td>
<td>A14/A15</td>
</tr>
<tr>
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<td>F1/A14</td>
<td>F8/F11</td>
<td>F12/A12</td>
<td>A6/A14</td>
<td>A14/A16</td>
</tr>
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<td>F1/F7</td>
<td>F3/F6</td>
<td>F8/F12</td>
<td>F12/A14</td>
<td>A6/A16</td>
<td>A14/A18</td>
</tr>
<tr>
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<td>F4/F7</td>
<td>F11/A12</td>
<td>F12/A15</td>
<td>A12/A13</td>
<td>A15/A21</td>
</tr>
<tr>
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<td>F5/A16</td>
<td>F11/A13</td>
<td>A1/A16</td>
<td>A12/A16</td>
<td>A16/A20</td>
</tr>
<tr>
<td>F1/F10</td>
<td>F6/F7</td>
<td>F11/A14</td>
<td>A5/A16</td>
<td>A13/A16</td>
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### Table 3

**Item-Item Correlations (N = 51)**

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<th>R2T1</th>
<th>R2T2</th>
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<td>.94</td>
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<td>.92</td>
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<td>.94</td>
<td>.93</td>
<td>.92</td>
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<td>.88</td>
<td>.71</td>
<td>.82</td>
</tr>
<tr>
<td>F4/F6</td>
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<td>.90</td>
<td>.93</td>
<td>.91</td>
<td>.91</td>
</tr>
<tr>
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<td>.92</td>
<td>.91</td>
<td>.85</td>
<td>.90</td>
</tr>
<tr>
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<td>.92</td>
<td>.91</td>
<td>.85</td>
<td>.89</td>
</tr>
<tr>
<td>F7/F9</td>
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<td>.92</td>
<td>.89</td>
<td>.85</td>
<td>.88</td>
</tr>
<tr>
<td>F8/F9</td>
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<td>.92</td>
<td>.87</td>
<td>.89</td>
</tr>
<tr>
<td>F9/F10</td>
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<td>.89</td>
<td>.81</td>
<td>.91</td>
<td>.88</td>
</tr>
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<td>A16/A17</td>
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<td>.92</td>
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<td>.91</td>
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</table>
**Item Difficulty**

The four data sets in the 'without seat' condition, specified for each of two raters on each of two occasions, in the first reliability study (Fife et al., 1991) were used to determine the item difficulty. The mean was calculated for each of the 34 items in each of the four data sets and a summary difficulty index for each item calculated as the mean of the difficulty indexes for each item across the data sets. Results are displayed in Table 4. Three of the mean item difficulty indices exceeded the preset level as stated in hypothesis 2 (3.50 for multi-point items and 3.83 for two-point items) of maximum preferred item difficulty for the 'without seat' condition.
Table 4

Item Difficulty Index for SPCM Items (N=41)\(^a\)

<table>
<thead>
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<th>R2T1</th>
<th>R2T2</th>
<th>Mean</th>
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<td>3.08</td>
<td>3.26</td>
<td>3.27</td>
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<td>3.42</td>
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</tr>
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<td>2.57</td>
</tr>
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<td>2.94</td>
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<td>1.58</td>
<td>1.43</td>
<td>1.52</td>
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</table>

\(^a\)Multi-point items are in plain text; two-point items are in bold text.
Item Discrimination

The eight data sets established for the combinations of raters, occasions and conditions in the first reliability study (Fife et al., 1991) were used to assess item discrimination. The individual gain discrimination index ($DIS_{IG}$) was determined for each combination of raters and occasions by calculating the proportion of scores which increased from the pre-seating to the post-seating condition. The discrimination indices for each rater and occasion as well as the mean ($DIS_{IG}$) are displayed in Table 5 for each item. Twelve of the 34 mean discrimination indices were less than the predefined 0.2 minimum desirable level, as stated in hypothesis 3.

The mean proportion of children whose scores decreased from the pre-seating to the post-seating condition was calculated for each item and displayed in Table 6 with the mean $DIS_{IG}$ and the proportion of children whose scores were unchanged. The mean $DIS_{IG}$ was greater than the proportion of children whose scores decreased for 30 of the 34 items, including all 22 of the items with a $DIS_{IG}$ exceeding 0.2.
Table 5

Individual Gain Discrimination Index (DIS(G)) (N=41)

<table>
<thead>
<tr>
<th>Item</th>
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<th>R1T2</th>
<th>R2T1</th>
<th>R2T2</th>
<th>Mean</th>
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Table 6
SPCM Item Score Changes from 'Without' to 'With' Seating Condition (n=41)

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<th>Proportion Increased (DIS_{IG})</th>
<th>Proportion Decreased</th>
<th>Proportion Unchanged</th>
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To test hypothesis 4, the same four data sets from the second reliability study (Fife et al., 1993a) used to examine item homogeneity were also used to examine item-subscale congruence for the four alignment subscales and the one function subscale. Subscale scores were calculated with the item removed and scatter plots of item-subscale combinations examined. Only one item-subscale combination (Fl/Function Subscale) was found to not meet the assumptions of the correlation coefficient and was thus excluded from the analysis. The Spearman rank correlation coefficient was calculated for each of the remaining item-subscale combinations. The mean item-subscale correlations for the alignment items are displayed in Table 7 for each of the alignment subscales and the function items in Table 8 for each of the section scores.

Seventeen of the alignment items were more highly correlated with the subscales to which they were assigned than to other alignment subscales. Three of the pelvis items and two of the trunk items had higher correlations to other than the assigned subscales. All function items were more highly correlated with the function section score than with the alignment section score.
### Table 7

**Mean Item-Subscale Correlations for Alignment Items (N = 51)**

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Table 8

Mean Item-Section Correlations for Function Items (N = 51)

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<th>Item</th>
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</thead>
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Subscale-section Congruence

In testing hypothesis 5, the same four data sets used to examine item homogeneity and item-subscale congruence were used to examine subscale-section congruence for the alignment subscales. The alignment section scores were calculated with each of the subscale scores removed. Scatter plots of subscale-section combinations were examined and all subscale-section pairs were found to meet the assumptions for use of the correlation coefficient. The Pearson product-moment correlation coefficient was calculated (specifying pair-wise deletions) for each of these combinations and a correlation matrix constructed for each of the four data sets. The mean subscale-section correlations are displayed in Table 9. Alignment subscales were more highly correlated with the Alignment section than with the Function section with the exception of the Head subscale.
Table 9

Mean Section-Subscale Correlations for Alignment Subscales (N = 51)

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CHAPTER V DISCUSSION

The purpose of this study was to analyze the item and subscale properties of the Seated Postural Control Measure (SPCM) to determine: 1) whether item function was consistent with the purpose of the measure; and, 2) whether the items were appropriately placed within the theoretically-derived subscales. Five research hypotheses, specifying anticipated item and subscale statistical properties, were generated from a review of the literature and prior SPCM development activities. Properties examined were item homogeneity, item difficulty, item discrimination, item-subscale congruence and subscale-section congruence.

Item homogeneity was assessed, using the Spearman rank correlation coefficient, to determine whether any items were not contributing unique information to the test and could thus be eliminated. Homogeneity of 37 item pairs could not be examined using the correlation coefficient because the assumptions underlying the use of this coefficient were not met (Table 2). The mean correlation for only one of the 524 item pairs examined exceeded the 0.95 cut-off point for item redundancy and thus 33 of the 34 items could be considered to be contributing unique information to the test. The item pair which exceeded the cut-off point was F11/F12 (r_s = .99) indicating that little additional information was gained from having two rather than one of these item pairs on the test. It is unlikely that these two items are measuring separate aspects of wheelchair propulsion (speed and accuracy) as was intended in the item design. It is therefore recommended that one of these items be deleted from the test to decrease the test administration time and the response burden. F11 is recommended for deletion because it is the more difficult of the two items to administer. This item requires a long testing area (45 feet by eight feet) which may not be readily available at all potential testing sites. Deletion of this item will necessitate a recalculation of the Function section score reliability which may decrease slightly because of the decrease in the number of items.

Item difficulty was examined in the 'without seat' condition to determine whether item difficulty was sufficiently low to allow item scores to have the potential to improve following
seating intervention. Hypothesis 2 specified different maximum difficulty levels for multi-point items (scored one to four) and two-point items (scored three or four). None of the mean difficulty indices for the six two-point items exceeded the preset level of 3.83. For the 28 multi-point items, three of the mean difficulty indices exceeded the preset level of 3.50. Items exceeding the cut-off point were A19-Upper Trunk Rotation, A20-Head Rotation, and Fl-Head Lifting. The high item difficulty for these items indicates that most participants scored highly in the 'without seat' condition and therefore little positive change could be expected post-intervention.

For A19 and A20, the likely explanation for the high difficulty indices is the item scaling. The width of the scale increments was 20 degrees for A19 and 30 degrees for A20, with the midpoint for the greatest angular deviation set at 60 degrees and 90 degrees respectively. It appears that the high angular deviation required to assign a score of 1 (severe category) resulted in this score category never being used for A19 and for only two of the 146 item scores for A20. Scales for these items were revised as part of the test refinements which were done following the first reliability study. The angular deviation for the severe category was re-set to 35 degrees for both A19 and A20. This change will likely result in a lower item difficulty although data were not available to calculate the item difficulty on the revised test in the 'without seat' condition.

The high item difficulty index for item Fl is less easily explained. Although item difficulty was expected to be higher for the head control items than many of the other test items, because of the ease of this motor task, the pre-set item difficulty level should still not have been exceeded. Further examination of this item reveals that the full range of possible scores were assigned and therefore the scaling does not appear to be flawed. Later discussion of the item difficulty in relation to the item sensitivity addresses whether the scaling requires modification or whether items should be retained without modification because a negative change is possible.

An initial exploration of item sensitivity or item responsiveness was undertaken by calculating the individual gain discrimination index (DISIG) for each item. Hypothesis 3 specified the minimum preferred discrimination index (the proportion of subjects whose scores improved from the 'without seat' to the 'with seat' condition) for each item as 0.2. Twelve of the thirty-four
mean item discrimination indices fell below the 0.2 cut-off point (Table 5). One Alignment Section item, A14 - Right Knee Flexion/Extension, and eleven of the twelve Function section items had discrimination indices less than 0.2.

There are two possible explanations for the DIS$_{IG}$ exceeding the preset level for most of the Alignment items. The first explanation is that the Alignment items are detecting true score change in the anticipated direction as hypothesized. A competing explanation is that item score variability may have resulted in chance increases or decreases in scores following the intervention. This explanation must be considered because the DIS$_{IG}$ was calculated using participant data from the first reliability study which had low interrater and test-retest reliability estimates for some of the Alignment items. To determine whether the latter explanation is excluded, the proportion of children whose scores decreased for each item from the 'without' to the 'with' seat condition was calculated (Table 6). All but two of the Alignment items (A5 and A6) had a substantially higher proportion of subjects whose scores increased than decreased, thus supporting the former explanation for the DIS$_{IG}$ exceeding the pre-set level for most of the Alignment items. Chance variability may explain the DIS$_{IG}$ exceeding 0.2 for A5 and A6 as indicated by the similar proportion of scores which decreased as increased for these items.

The most probable explanation for the low DIS$_{IG}$ for A14 is the relatively high difficulty index in the 'without seat' condition. The difficulty index for A14 was 3.74, just below the cut-off level for two-point items and the highest of all limb items. The high difficulty index is probably a reflection of the magnitude of the scale increments selected for this item. The 'normal' category increment was originally set at ±45 degrees to accommodate the wide range of sagittal plane knee angles which might be required in a seating system because of fixed knee contractures and which were unlikely to change with seating intervention. It appears however, that setting this broad width to the 'normal' category has resulted in a potential loss of item sensitivity to change. A recommended revision for this item is to narrow the scale increment for a score of four from ±45 degrees to ±30 degrees. This revision would likely lower the item difficulty index in the 'without' seat condition because fewer children would receive the maximum score. With this revision, the
item would have a greater capacity to change post-seating. This revision to the scale increment width is also recommended for item A15 which is the comparable item for the left leg.

Within the Function Section, only F2 - Maintains Head Upright in Midline, had a discrimination index above the 0.2 cut-off point and even this item, with a DIS\textsubscript{IG} of 0.21, did not exceed the cut-off by a large margin. Furthermore, the DIS\textsubscript{IG} for F2 did not exceed the proportion of decreased scores beyond that which would be anticipated by chance. There are three possible explanations for the low discrimination indices for the remaining 11 Function section items. The first explanation is that these items are not responsive to changes in postural control resulting from adaptive seating intervention. A second possibility is that the items are responsive but the changes were not in the anticipated direction. The third explanation is that adaptive seating, as prescribed for this sample, did not result in changes in motor function.

Considering the discrimination index in relation to the difficulty index provides a possible explanation for the low DIS\textsubscript{IG} for F1. Because F1 had such a high difficulty index (3.71) in the 'without seat' condition, little positive score change was possible post-seating intervention. The need for revisions to this item, as suggested in the discussion of the item difficulty findings, is further supported by the low discrimination index.

To attempt to determine which explanation best accounted for the low DIS\textsubscript{IG} for the remaining function items, the proportion of subjects whose scores decreased and those whose scores were unchanged from the 'without' to the 'with seat' condition (Table 6) were further examined. The proportion of subjects whose scores decreased ranged from 0.1 to 0.22 and the proportion unchanged ranged from 0.62 to 0.92. For five of the function items, more than ten percent of the subjects' scores decreased; a result which exceeded the proportion of subjects whose scores increased for items F3-F6. These four items each assess an aspect of trunk control during active reach or arm lifting. Rater debriefing following the test sessions elicited comments regarding the perceived decrease in functional motor skills for those items requiring trunk movement. The raters' impressions were that trunk movement was restricted by the shoulder strapping systems in many of the seats; and, that trunk movement was freer in the 'without seat'
condition. These rater impressions are supported for the portion of the children tested whose scores decreased for items F3-F5 from the pre-seating to post-seating condition.

The low discrimination indices for items F6 to F12 appear to be due to the large proportion of children whose scores were unchanged from the 'without' to the 'with seat' condition rather than attributable to decreasing scores. Items F6 to F10 each assess an aspect of upper limb function which does not require a great amount of trunk mobility. Items F11 and F12 assess wheelchair propulsion speed and precision respectively. Although not intended as an exclusive test of upper limb function, for the majority of children assessed, these two item tasks involved use of the arms either to propel a manual wheelchair or to manipulate the joystick of a power wheelchair. All of the items for which unchanged scores accounted for the low DIS\text{IG} could be considered upper limb function items and unchanged item scores are thus less likely to be interpreted as a chance occurrence. Rather, the low DIS\text{IG} should be interpreted as either reflecting an item flaw which is common to these six items, or, a true lack of change in upper limb function resulting from adaptive seating.

There is some literature support for the later explanation, that adaptive seating does not improve aspects of upper limb function for children with neuromotor disabilities. In a two-period cross-over study, Gross (1989) found no effect of adaptive seating on upper extremity control during a reaching task as measured by wrist velocity, wrist trajectory and length of reach for six children aged two to 11 years. Partially supporting Gross's finding, Hulme and colleagues (1987), in a prospective time series study of 19 children ranging in age from one to four years, found no effect of adaptive seating on reach but some effect on grasp. McPherson et al. (1991) also found no difference in reach for three adults with cerebral palsy pre- and post-seating.

All of these research findings tend to support the possibility that the SPCM upper limb function items were not flawed but rather registering stable scores in the absence of change. Because it is not known whether true changes in postural control occurred under the two seating conditions of the SPCM study, the question of item responsiveness cannot be fully answered at
this time. A further study is required, utilizing a change questionnaire or second change measure, to build the required evidence for establishing item responsiveness.

In the absence of evidence of true change in postural control (due to the lack of an external criterion) one can only conclude that nineteen of the SPCM items appear to have the potential to be responsive and 15 items may not possess this property. The alignment section items are more likely to detect changes resulting from adaptive seating intervention than are the function section items. Because the SPCM was designed to assess potential seating outcomes at two distinct levels, impairment and functional limitations as defined in Haley's model (1992), it is possible that adaptive seating positively affects impairments but not functional limitations.

Item-subscale congruence and subscale-section congruence were determined by examining correlations within and across subscales. Hypothesis 4, which specified greater correlations of items with subscale scores to which the item was assigned than to other subscales, was upheld for 17 of the alignment items and all of the function items. Statistical support is thus provided for the clinical subscale grouping of the function items, head items, and limb items. There is no statistical support for the subscale grouping of the pelvic items nor for the inclusion of two of the six trunk items in the trunk subscale grouping. Although a clinical rationale may exist for maintaining these subscale groupings, caution is recommended in interpreting subscale scores for the trunk and pelvic subscales. Unlike the other subscales, these two subscales are not considered homogeneous in content and thus scores should not be interpreted as reflecting a unified pelvic or trunk alignment score but rather a summary score of heterogeneous items. For example, the assumption cannot be made that a high subscale score reflects uniformly high item scores as could generally be assumed for other subscales which had high item-subscale correlations. Johnston and colleagues (1992) cautioned that a collection of raw scores comprising multiple dimensions is heterogeneous and should not be summed as if they measured a single dimension. Because pelvic and trunk items tend to be similarly correlated with both the Pelvis subscale and the Trunk subscale, consideration should be given to combining these subscales into a single Pelvis/Trunk subscale.
Subscale-subsection congruence was evaluated by correlating Alignment subscale scores with section scores. All Alignment subscales, except the Head subscale, were found to be more highly correlated with the Alignment section score than with the Function section score, providing general statistical support for this first level of SPCM subscale structure. The substantially higher correlation of the Head subscale with the Function section than with the Alignment section may be an indication that the Head subscale items more appropriately belong in the Function section. Because the head is frequently unrestrained in a seating system, the inability to maintain a neutral head alignment (as measured by the head alignment items) may be little different than head righting in response to a task demand (as measured by the head function items). If the Head subscale is to remain in the Alignment section, caution is advised in attempting to make assumptions regarding Head subscale scores from Alignment section scores because of the low correlation between these scales.

Limitations

Several limitations affect the strength of the conclusions which can be drawn from this study. The first limitation is due to the retrospective nature of this study which involved secondary analysis of data from two previous reliability studies (Fife et al., 1991; Fife et al., 1993a). Data were missing for some items in both studies with the highest numbers missing for Fl 1 and F12. Although strategies for handling missing data were devised, the absence of some item scores may have decreased the representativeness of the sample for some items. Other limitations inherent in retrospective research are the inability to fully explain the reasons for missing data or to explore raters' undocumented impressions due to forgetting with the passage of time.

A second study limitation is the sample size. According to Nunnally (1964), one of the most important criteria for conducting an item analysis is a large subject sample. In discussing teacher-made tests, he suggested taking item analysis results seriously only if they are based on at least 40, and preferably 100, subjects. The SPCM item properties assessed in this study were judged based on 41 participants for hypotheses 2 and 3; and, 51 participants for hypotheses 1, 3
and 5. Missing scores for some items decreased the sample size slightly for these items. For the examination of item difficulty and item discrimination, the sample size was on the borderline of acceptability as recommended by Nunnally. However, use of the eight separate data sets for each subject may have partially compensated for the smaller number of participants.

A third limitation was the poor reliability of some of the alignment items in the data which were used to examine hypotheses 2 and 3. Because reliability (particularly test-retest) was found to be low (Fife et al., 1991) data sets from the original reliability studies were not combined when analyzing item properties in the current study. Instead, item property indices were calculated for each data set and then summarized across data sets by computing the mean. However, the separate analysis of data sets does not obviate the need to interpret results in light of the estimated reliability.

A further limitation involving item reliability relates to hypothesis 1. Setting the cut-off level for acceptable inter-item correlations at 0.95 may have limited the capacity to detect redundant items if the reliability of one of the item pairs was below the cut-off point. Reliability estimates of many of the Alignment items involved Weighted Kappa coefficients below this preset level and thus the test of item redundancy may have been most appropriate for the Function items (which had higher item reliabilities).

A fourth limitation specifically relates to the strength of the conclusion addressing item discrimination or responsiveness. Assessment of item discrimination in the absence of an external measure of change cannot be conclusive (Boyce et al., 1992; Guyatt et al., 1987; Meenan et al., 1984; Rosenbaum et al., 1990). To fully assess SPCM item responsiveness, a prospective study utilizing an additional change measure to gauge the true occurrence of change is required. Once it is established that the measure is detecting a true change in seated postural control, an additional consideration is the clinical importance of such change. Jaeschke and colleagues emphasized the need to determine the minimal clinically important difference for an evaluative test and suggested methods of estimation for specified patient groups (Jaeschke, Singer, & Guyatt, 1989). Because it is not known whether true change in seated postural control occurred in the current study from the pre-seating to post-seating condition, nor the degree of change which is clinically significant, firm
conclusions cannot be drawn about item or test responsiveness. The current study is thus only a preliminary investigation of potential responsiveness and provides only a hint of what may be revealed in future studies.

A fifth limitation involves the ordinal level of item data. Because the scale intervals are not equal, use of the mean as the item difficulty index may be a source of misinterpretation, particularly if one attempts to compare the relative magnitude of item difficulties. For example, one can only infer that an item difficulty of three is higher than a difficulty of two, not that an item difficulty of three is the same amount above two as two is above one. Misinterpretation of ordinal data is a common occurrence in rehabilitation research and must be guarded against in any attempts at further score interpretation (Merbitz, Morris, & Grip, 1989).

**Implications and Suggestions for Future Research**

The current study is an important step in the ongoing development of the SPCM. Statistical review of item and subscale properties augments the judgmental review conducted during the conceptualization phase of test development. The implication of this preliminary item analysis is that the SPCM has the potential for use as an evaluative seating measure, pending the results of further test development and validation studies. If the items which were suggested for review or modification are changed, reliability assessment of the revised items will be required. If the number of scale items changes through deletion or reassignment, recalculation of the reliability of affected subscales and section scores is also required. Recalculation of reliability will be required because decreasing the number of items will decrease the rater and respondent burden but will likely also result in a decrease in reliability (Berk, 1984; Crocker & Algina, 1986; Streiner & Norman, 1989).

Future research should be directed at demonstrating the true responsiveness of the SPCM as a whole and of individual items using a design which overcomes the limitations of the current study. In the absence of a test of known responsiveness or a treatment of known effectiveness, techniques were devised to assess the responsiveness of two new gross motor measures (Boyce et
al., 1992; Russell et al, 1993). Developers of these measures tested a priori hypotheses of how children's scores were anticipated to change under various conditions and correlated these change scores with an external measure of change. The external change criteria used for these studies were parent and therapist ratings of the direction and degree of change. A similar approach could be used to assess the responsiveness of the SPCM. A priori hypotheses of how SPCM scores are anticipated to change under various conditions and how these changes in SPCM scores are correlated with an external estimate of change could be specified and tested. The external change measure must be capable of detecting changes in both directions because it is not known whether seating outcomes are positive or negative. Results of such a responsiveness study would provide additional evidence for the validity of the SPCM and its appropriateness for use in future seating outcome studies. Estimation of the minimal clinically important difference is also required to assist in score interpretation in future intervention studies. Techniques suggested by Jaeschke and colleagues (1989) could be used to estimate the minimal clinically important difference in SPCM scores for specific patient groups.

**Summary and Conclusions**

This study examined the statistical properties of the items and subscales of the SPCM to determine whether items were functioning as intended and whether there was statistical support for the theoretically-derived subscales. Item and subscale properties examined included item homogeneity, item difficulty, item sensitivity, item-subscale congruence and subscale-section congruence.

The degree of item homogeneity was deemed to be appropriate for all but one of the item pairs. F11 was recommended for deletion based on this finding. Item difficulty was higher than anticipated for three of the 34 items in the pre-seating condition; suggesting modifications of these items may be required.

Item sensitivity, as assessed using the individual gain discrimination index (DIS\_IG), was lower than expected for twelve of the 34 items. Possible causes of the low discrimination index
for these items were poor item responsiveness, lack of change in postural control from the pre-
seating to the post-seating condition; or, the occurrence of a negative change. Because of these
multiple possible explanations, the true responsiveness of SPCM items cannot be determined
without a further study utilizing an external change measure. Achieving the DISIC criterion level
could not be considered an indication of potential item responsiveness for three of the items (A5,
A6 and F2) because a similar proportion of participants had decreasing scores, indicating chance
variability.

The current study provided statistical support for the grouping of SPCM items into the
Function scale and two of the four Alignment subscales. There is no statistical support for separate
groupings of the Pelvis and Trunk Alignment subscales. Grouping of Alignment subscale scores
into Alignment section scores was supported for all but the Head subscale.

A number of limitations affected the strength of the conclusions which could be drawn
from this study. The retrospective nature of the study limited the ability to avoid or fully explain
missing data. The small sample size for some items may have restricted the generalizability of
findings. In addition, the poor reliability of some of the item data used to test hypotheses 2 and 3
limited the certainty of conclusions for these hypotheses. The further lack of an external measure
of change rendered the item discrimination index only a preliminary indicator of item
responsiveness. The ordinal level of the items also limited the interpretation of the item difficulty
index.

Additional test development is required to modify faulty items and then reassess reliability.
Subsequent research should focus upon the evaluation of item and test responsiveness as well as
the estimation of the minimal clinically significant difference.
REFERENCES


APPENDIXES

<table>
<thead>
<tr>
<th>Appendix 1</th>
<th>SPCM Item Specifications (Roxborough, Fife, Story, 1995)</th>
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</thead>
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<td>Appendix 2</td>
<td>SPCM Record Form: Draft 4 (Fife, Roxborough, Story, 1990a)</td>
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<tr>
<td>Appendix 3</td>
<td>SPCM Guidelines: Draft 4 (Fife, Roxborough, Story, 1990b)</td>
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<tr>
<td>Appendix 4</td>
<td>SPCM Record Form: Draft 8 (Fife, Roxborough, Story, 1993b)</td>
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<tr>
<td>Appendix 5</td>
<td>SPCM Guidelines: Draft 8 (Fife, Roxborough, Story, 1993c)</td>
</tr>
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</table>
Appendix 1  SPCM Item Specifications

General Item Specifications

- Items must measure an aspect of postural control which is expected to change as a result of adaptive seating intervention. All aspects of postural control which have the potential to change should be included.

- Items must be feasible to administer in a clinical setting. The equipment required for administration must be readily available in a clinical setting and the time involved to administer the item must not be excessive.

- The response burden for the child must not be excessive particularly in terms of cognitive and language demands.

- The items must have the capacity for graded responses to allow scaling which will capture the degree of change in the aspect of postural control being assessed.

- Items must be capable of being administered while the child is seated in an adaptive seating system.

- Item responses should not require "hands on" assistance as the degree of assistance provided is difficult to standardize.

- Items should have face validity, i.e., be engaging for the child if their active response is required and appear valid to the clinicians who will ultimately be using the test. Items should also appear valid to the parents of the children being tested.

- Items must be safe to administer in a clinical setting.

- Items must involve therapist ratings rather than child or parent interview ratings as the SPCM is being designed to measure behaviors that the child demonstrates during testing rather than behaviors which are reported.

- Items must not compromise the dignity of the child, e.g., items requiring clothing removal should be avoided.

Domain Specifications

Two test domains were identified through a review of postural control theory and by grouping the lists of postural control seating goals generated by clinicians and those discussed in the seating literature. The test domains which seemed to emerge were subsequently labeled "alignment" and "functional movement". Additional item specifications were developed for items in each of these domains.

Alignment domain specifications required that the items assess an aspect of body segment alignment which was thought to change as a result of adaptive seating intervention and which could be scored using visual inspection and palpation only.

A function domain specification was that items had to involve a task goal and must be meaningful to the child. Functional movement items should not measure the movement strategy used by the child to perform a given task but rather the degree to which the movement goal (i.e., the task) is achieved.
Appendix 2  SPCM Record Form (Draft 4)
(used in 1991 reliability study)
<table>
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<th><strong>SEATED POSTURAL CONTROL MEASURE</strong></th>
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<tr>
<td><strong>SUNNY HILL HOSPITAL FOR CHILDREN</strong></td>
<td><strong>DRAFT 4</strong></td>
</tr>
<tr>
<td>3644 Slocan Street, Vancouver, B.C. V5M 3E8</td>
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<th><strong>Yr</strong></th>
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<th><strong>Day</strong></th>
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<td></td>
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<td></td>
<td>TOTAL</td>
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**Name_________________________**  
**I.D. No_______________________**  
**Diagnosis____________________**  
**Date onset of problem________**  
**Referring physician___________**  
**Assessor_____________________**

---

**LEVEL OF SITTING ABILITY**  
Check category below (see Guidelines)

- **0** unplaceable
- **1** supported from head downward
- **2** supported from shoulders or trunk downward
- **3** supported at pelvis
- **4** maintains position; does not move
- **5** shifts trunk forward, re-erects
- **6** shifts trunk laterally, re-erects

**Was the test administered with child in seating system?**  
Yes [ ]  No [ ]

If yes, complete seating system description and checklist below.  
If no, check method of support used:

a. **Tumbleform**  
   - Small [ ]  
   - Medium [ ]  
   - Large [ ]
   - Tilt in space: [ ] degrees inclination of seat-back

b. **Bench with feet supported**

c. **Other**

**Description:**

---

**Description of Seating System used for this test:**

**Date last modified:**

**Is present fit adequate?**  
Yes [ ]  No [ ]

**Type of system and general comment:**

---

**Indicate seating system orientation in degrees:**

- [ ] seat-to-back angle
- [ ] angle of seat back recline related to vertical plane (tilt in space)

**Check seating system components which are present:**

**Pelvis:**
- [ ] pelvic stabilizer
- [ ] ASIS pads
- [ ] pelvic bar
- [ ] pelvic belt
- [ ] safety belt
- [ ] lateral support

**Trunk:**
- [ ] lateral thoracic support
- [ ] lumbar support
- [ ] anterior trunk support
- [ ] at shoulder
- [ ] chest panel

**Thigh:**
- [ ] medial support
- [ ] lateral support

**Knee:**
- [ ] anterior support

**Interface surface:**

- [ ] planar
- [ ] contoured

**Head and Neck:**

- [ ] circumferential head and neck support
- [ ] head support
- [ ] posterior
- [ ] anterior
- [ ] lateral
- [ ] posterior neck support

**Upper limbs:**

- [ ] tray
- [ ] custom arm rests
- [ ] posterior blocks
- [ ] scapulae
- [ ] elbows
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<th>Mild</th>
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* Degrees of angulation
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<th>Moderate 1</th>
<th>Severe 0</th>
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</table>

* Degrees of angulation

SCORE: Page 3
SEATED POSTURAL CONTROL MEASURE: FUNCTION SECTION
DRAFT 4

Child's name ____________________________________________________________

Assessor ______________________________________________________________

Date of Assessment ______________________________________________________

Administered with seating system Yes ____ No ____

Circle score for each item.

1. Lifts head upright and maintains 3 sec
   - If child's head is not flexed forward prior to test, instruct or assist child to do so. Upright position of the head is defined as that position where central gaze is directed along the horizontal plane.
   - 0. does not initiate head lift
   - 1. initiates a head lift
   - 2. lifts head, does not attain upright, but holds for 3 sec
   - 3. lifts head upright and maintains for 3 sec

2. Lifts head upright, in midline and maintains 10 sec
   - If child's neck is not flexed forward prior to test, instruct or assist child to do so.
   - 0. does not initiate head lift
   - 1. initiates a head lift but does not attain midline
   - 2. attains midline but maintains for less than 10 sec
   - 3. lifts head to midline and maintains for 10 sec

3. Leans forward, touches toy with preferred wrist or hand, re-erects
   - Small toy placed on board at child's midline at a distance 1-1/2 times 'arm length' anterior to trunk midline.
   - 0. does not lean forward and re-erect
   - 1. leans forward but does not touch toy
   - 2. leans forward, touches toy, but does not re-erect
   - 3. leans forward, touches toy, re-erects
4. Leans forward and to right or left, touches toy with OPPOSITE hand, re-erects

The intent of this item is to obtain trunk rotation; either hand may be used. Small toy placed on board in front of child on side opposite to the reaching hand. Place toy 1-1/2 times arm length of the reaching arm along the layout guide marker line which runs 60 degrees from trunk midline.

0. does not move trunk
1. leans towards toy but does not touch it
2. leans towards and touches toy with hand, does not re-erect
3. leans towards and touches toy with hand, re-erects

5. Lifts both upper limbs free of support, touches face or head

0. does not lift either upper limb off support
1. lifts RIGHT or LEFT upper limb off support for 3 sec
2. lifts BOTH upper limbs off support for 3 sec
3. lifts BOTH upper limbs off support for 3 sec and places BOTH hands simultaneously on face or head

6. Reaches forward, grasps and releases toy with preferred hand

Small toy placed on board an 'arm length' anterior to the trunk midline.

0. does not touch toy
1. touches toy with palm or fingers
2. grasps toy and lifts it off board for 3 sec
3. releases toy into large container placed conveniently by therapist

7. Picks up raisin (or Cheerio), places in mouth with preferred hand

Raisin placed on board at any location which accommodates child's attempts to pick up raisin.

0. does not touch raisin
1. touches raisin with tips of fingers and/or thumb
2. picks up raisin and holds 3 sec
3. releases raisin in mouth

8. Removes and replaces lid of screw-type jar

Jar placed on board anterior to child's midline at any location which accommodates child's attempts to grasp jar.

0. does not touch jar
1. places one or both hands on jar
2. unscrews and removes jar lid
3. replaces jar lid and screws it closed
9. **Picks up pen, makes a mark**

Pen and 8-1/2 x 11" paper placed midsline on board, pen tip pointing toward child.

0. does not pick up pen
1. picks up pen with one or both hands
2. grips pen in position to mark paper
3. holds paper and marks it with pen

10. **Places dice in jar, one at a time, with preferred hand, in 30 sec**

Place dice and jar on board as indicated by paper guide immediately in front of child. Request child to place dice into jar, one at a time, using one hand, as fast as possible. If at end of time period child has picked up a die but not completed placing it in the jar give credit for that die.

0. does not place any dice in jar
1. places one die
2. places 2 to 5 dice
3. places 6 dice

11. **Moves his/her wheelchair forward 45' in less than 20 sec**

Allow one practice trial to ensure child understands the task.

0. unable to move wheelchair forward
1. moves wheelchair forward 10' in less than 60 sec
2. moves wheelchair forward 45' in less than 60 sec
3. moves wheelchair forward 45' in less than 20 sec

12. **Moves his/her wheelchair forward 10' along 8' wide corridor, turns right or left 90° and passes through 33" doorway**

Allow one practice trial to ensure child understands the task. Maximum of 60 seconds allowed for completion of the task.

0. does not move wheelchair forward 10' without bumping into walls
1. moves wheelchair forward 10' but does not initiate a turn
2. moves wheelchair forward 10' and turns to face doorway
3. moves wheelchair forward 10', turns and passes freely through doorway

**TOTAL SCORE FUNCTION SECTION __________ (MAX. = 36)**

Enter score on Page 1
Appendix 3  SPCM Guidelines (Draft 4)  
(used in 1991 reliability study)
The purpose of this measure is to evaluate change in postural alignment and control in children who have been prescribed adaptive seating systems. It is intended that administration will take about 20 minutes and will require little in the way of special equipment. All items are administered while the child is sitting. The measure may be administered while the child sits in a prescribed seating system or with any other means of seated support, other than manual support.

The measure is divided into two sections, Alignment and Function. Guidelines for administration of the two sections are described below.

**EQUIPMENT**

1. Small toy
   
   This will consist of 2 Duplo blocks stuck together to form a block with dimensions of 2.5" x 1.25" x 1.5". Hooked Velcro is glued on the largest surface of the block.

2. Ruler - rigid yard or meter stick

3. Stopwatch

4. 2' x 2' positioning board = two layers of 'tenplast'

5. Plastic coated layout guide. This is a sheet of 8 1/2" x 11" (will be illustrated)

6. Dice - 6, roughly 1/2" cubes

7. Sticky-back Velcro bits, 1/4" square to place at target sites

8. Pen - marker pen, approximately 1/2" diameter or adapted pen/pencil used by child

9. Raisins (or Cheerios, if deemed more safe for child)

10. Sheet of paper - 8 1/2" x 11"

11. Jar - 90 cc Urine Specimen jar, diameter = 2", height = 3"

12. Container - any open container (such as a bowl) with at least a 5" diameter opening

13. Goniometer

14. Inclinometer (hardware store variety)

15. Bench or High Mat for testing level of sitting, feet unsupported

16. Footstools
SECTION 1 ALIGNMENT

All items are administered while the child is sitting. The therapist may palpate bony reference points when observing alignment but should not provide manual support or correct the child’s position after initial correct placement of the child in the seat.

The procedure for grading the 'Level of Sitting Ability' is described on a separate instruction sheet.

Position References:

Positions of the axial skeleton (with the exception of trunk rotation) are described according to the orientation in space. Limb joint positions are described according to joint angle using terminology of the American Academy of Orthopedic Surgeons.

The orientation of the seating support used by the child is described as follows:

**Seat-to-back angle:**
The angle between the planar surfaces (not the padded interface surfaces) of the seat and back. This angle may be measured with a goniometer or inclinometer.

**Tilt-in-space:**
The angle between the planar surface of the seat back and the vertical plane, e.g., the tilt-in-space when the seat back is in the vertical position is 0 degrees. The inclination of the seat back is best measured with an inclinometer.

Scoring

There are 17 alignment items listed in order of their observation from anterior, lateral and superior views. The posture of the axial skeleton is represented by 12 items and the limb positions by 5. There are 4 levels per item, with a score of 3 representing the normal erect sitting posture with approximately 90 degree angles at the hips, knees and ankles and scores of 2 to 0 representing mild, moderate and severe deviations from normal. The total score for the alignment section may range from 0 to 66.

Circle the score closest to the estimated observed angle. If the child frequently changes position, select the score estimated to be the most commonly sustained posture. If the estimation is exactly between two scores, select the score which reflects the worst posture. Note that limb joint positions may be asymmetrical and thus each limb may receive a different score. The scores for each limb position are added together.
SECTION 2  FUNCTION SECTION

All items are administered with the child in a sitting position. If the seating system has adjustable tilt-in-space, tests should be conducted at the usual 'working' tilt assumed by the child.

A positioning board will be used for all test items which require reach, grasp, or manipulation of objects. The board (2'x2', made of light, fairly rigid material such as 'tenplast') will be held horizontally by the therapist at approximately the child's waist height (or higher if necessitated by the system). It may help the assessor to steady the board on a cushion placed on the child's lap or on armrests, if present. However, if the child's seating system includes a tray, the board should rest upon the tray at the inclination regularly used by the child. (Note: inclination of the tray is one reason for using Velcro to mark the target location and prevent the target object from slipping.)

Roughly 1 minute should be allowed for motivating a child and completing each item. If several attempts are made during this time, score the best attempt. Use verbal and gestural encouragement but no "hands on" assistance or support.

Definitions

'Arms length' = distance from acromial angle to ulnar styloid process with arm passively outstretched maximally and flexed approximately 90° at the shoulder. When measuring from subject to target location, it is easiest to rest a rigid measuring stick on the board, then place a piece of sticky-backed Velcro no larger than 1/4" square at the measured location.

'Wheelchair' = manual or power mobility system regularly used by child. If the child has never attempted independent mobility in his/her wheelchair, the 2 mobility items will be omitted.

'Preferred hand' = which ever hand appears to be used most frequently by the child. Note which hand was used when scoring relevant items.
Appendix 4  SPCM Record Form (Draft 8)
(used in 1993 reliability study)
SEATED POSTURAL CONTROL MEASURE
SUNNY HILL HOSPITAL FOR CHILDREN
3644 Slocan Street, Vancouver, B.C. V5M 3E8

Yr Mo Day SCORE:  

Name__________________________ Date of Assessment ___ ___ ___  
I.D. No.______________________ Date of Birth ___ ___ ___  
Diagnosis____________________ Chronological Age ___ ___ ___  
Date onset of problem_________ Rater 1 2 3 4 5 6 7 8 9 10  
Referring physician___________ Test 1 2 3 4 5 6 7 8 9 10  

LEVEL OF SITTING SCALE  Check category below  (see Guidelines)

1  unplaceable  
2  supported from head downward  
3  supported from shoulders or trunk downward  
4  supported at pelvis  
5  maintains position; does not move  
6  shifts trunk forward, re-erects  
7  shifts trunk laterally, re-erects  

COGNITIVE LEVEL
Understands most instructions  
Understands few instructions  

COOPERATION LEVEL
Cooperates fully  
Cooperates with prompting  
Uncooperative  

Description of Seating System used for this test:
Date last modified:  
Is present fit adequate? Yes  
No  

Type of system and general comment:  

Indicate seating system orientation in degrees:  
  seat-to-back angle  
  angle of seat back recline related to vertical plane (tilt in space)  

Check seating system components which are present:

Pelvis:  
  pelvic stabilizer  
  ASIS pads  
  pelvic bar  
  pelvic belt  
  safety belt  
  lateral support  

Trunk:  
  lateral thoracic support  
  lumbar support  
  anterior trunk support  
  at shoulder  
  chest panel  

Head and Neck:  
  circumferential head and neck support  
  head support  
  posterior  
  anterior  
  lateral  
  posterior neck support  

Upper limbs:  
  tray  
  custom arm rests  
  posterior blocks  
  scapulae  
  elbows  

Interface surface:  
  planar  
  contoured  

Page 1 of 6
<table>
<thead>
<tr>
<th>SEATED POSTURAL CONTROL MEASURE: ALIGNMENT SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunny Hill Hospital for Children Vancouver, B.C.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>ANTERIOR VIEW</strong></th>
<th><strong>Please circle selections</strong></th>
<th><strong>NB: Circle and score R &amp; L limb positions individually.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Score: Descriptive Number</strong></td>
<td>Severe 4</td>
<td>Moderate 3</td>
</tr>
<tr>
<td>1. PELVIC OBLIQUITY</td>
<td>&gt;25*</td>
<td>15-24</td>
</tr>
<tr>
<td>Line joining ASIS's relative to horizontal</td>
<td>Right Side High</td>
<td>Left Side High</td>
</tr>
<tr>
<td>2. TRUNK LATERAL SHIFT</td>
<td>&gt;25*</td>
<td>15-24</td>
</tr>
<tr>
<td>Line joining sternal notch to midpoint between ASIS's relative to vertical</td>
<td>Shift to Right</td>
<td>Shift to Left</td>
</tr>
<tr>
<td>3. SHOULDERT HEIGHT</td>
<td>&gt;35</td>
<td>20-34</td>
</tr>
<tr>
<td>Line joining shoulders relative to horizontal</td>
<td>Right Side High</td>
<td>Left Side High</td>
</tr>
<tr>
<td>4. HEAD LATERAL TILT</td>
<td>&gt;35</td>
<td>20-34</td>
</tr>
<tr>
<td>Line joining outside corner of eyes relative to horizontal</td>
<td>Right Lateral Tilt</td>
<td>Left Lateral Tilt</td>
</tr>
<tr>
<td>5. R, G, L</td>
<td>&gt;35</td>
<td>20-34</td>
</tr>
<tr>
<td>HIP ROTATION</td>
<td>R L</td>
<td>R L</td>
</tr>
<tr>
<td>Angle of tibia relative to line joining ASIS's</td>
<td>Related to Right</td>
<td>Related to Left</td>
</tr>
<tr>
<td>7. PELVIC TILT</td>
<td>&gt;25*</td>
<td>15-24</td>
</tr>
<tr>
<td>Line from PSIS along posterior pelvis to seat surface relative to vertical</td>
<td>Posterior Tilt</td>
<td>Anterior Tilt</td>
</tr>
<tr>
<td>8. LUMBAR CURVE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1 - L5</td>
<td>Flexed</td>
<td>Extended</td>
</tr>
<tr>
<td>9. THORACIC CURVE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1 - T12</td>
<td>Flexed</td>
<td>Extended</td>
</tr>
<tr>
<td>10. TRUNK INCLINATION</td>
<td>&gt;35</td>
<td>20-34</td>
</tr>
<tr>
<td>Line joining posterior surface T1 and median of line joining PSIS's relative to vertical</td>
<td>Anterior Inclination</td>
<td>Posterior Inclination</td>
</tr>
<tr>
<td>Line joining corner of eye to tragus relative to horizontal</td>
<td>Anterior Tilt</td>
<td>Posterior Tilt</td>
</tr>
</tbody>
</table>
### SEATED POSTURAL CONTROL MEASURE: ALIGNMENT SECTION

**Please circle selections**

<table>
<thead>
<tr>
<th>Score:</th>
<th>Descriptive Number</th>
<th>Severe 4</th>
<th>Moderate 3</th>
<th>Mild 2</th>
<th>Normal 1</th>
<th>Mild 2</th>
<th>Moderate 3</th>
<th>Severe 4</th>
</tr>
</thead>
</table>

**RIGHT & LEFT LATERAL VIEWS**

12. R, 13. L  
**HIP FLEX/EXT**  
Angle relative to 90° flexion

14. R, 15. L  
**KNEE FLEX/EXT**  
Angle relative to 90° flexion

16. R, 17. L  
**ANKLE DORSI/PL FLEXION**  
Angle relative to 0 degrees

**SUPERIOR VIEW**

18.  
**PELVIC ROTATION**  
Line joining ASIS's relative to plane of the seat back

19.  
**UPPER TRUNK ROTATION**  
Line joining shoulders relative to frontal plane of pelvis

20.  
**HEAD ROTATION**  
Line joining ears relative to frontal plane of upper trunk

21. R, 22. L  
**HIP ADD/ABDUCTION**  
Angle of femur in relation to line joining ASIS's

**NB:** Circle and score R & L limb positions individually.
Circle score for each item.
Administer items 1 & 2 simultaneously, score separately.

1. **Lifts head upright and maintains 5 sec**

   If child's head is not flexed forward prior to test, instruct or assist child to do so. Upright position of the head is defined as that position where central gaze is directed along the horizontal plane (+/- 15° in sagittal plane).

   0. does not initiate head lift
   1. initiates a head lift
   2. lifts head, does not attain upright, but holds for 5 sec
   3. lifts head upright and maintains for 5 sec

2. **Lifts head upright, in midline and maintains 10 sec**

   If child's neck is not flexed forward prior to test, instruct or assist child to do so. Midline position of the head is defined as that position where central gaze is directed along the horizontal plane (+/- 5° in coronal plane).

   0. does not initiate head lift
   1. initiates a head lift but does not attain midline
   2. attains midline but maintains for less than 10 sec
   3. lifts head to midline and maintains for 10 sec

3. **Leans forward, touches toy with preferred wrist or hand, re-erects**

   Place board 6" from child's stomach. Small toy placed on board at child's midline at a distance 1'arm length' anterior to trunk midline.

   0. does not lean forward and re-erect
   1. leans forward but does not touch toy
   2. leans forward, touches toy, but does not re-erect
   3. leans forward, touches toy, re-erects
4. Leans forward and to right or left, touches toy with OPPOSITE hand, re-erects

The intent of this item is to obtain trunk rotation; either hand may be used. Small toy placed on board in front of child on side opposite to the reaching hand. Place toy 1-1/2 times arm length of the reaching arm along the layout guide marker line which runs 60 degrees from trunk midline.

0. does not move trunk
1. leans towards toy but does not touch it
2. leans towards and touches toy with hand, does not re-erect
3. leans towards and touches toy with hand, re-erects

5. Lifts both upper limbs free of support

0. does not lift either upper limb off support
1. lifts RIGHT or LEFT upper limb off support for less than 3 sec
2. lifts one upper limb off support for 3 sec
3. lifts BOTH upper limbs off support for 3 sec

6. Reaches forward, grasps and releases toy with preferred hand

Small toy placed on board an 'arm length' anterior to the trunk midline.

0. does not touch toy
1. touches toy with palm or fingers
2. grasps toy and lifts it off board for 3 sec
3. releases toy into large container set down in a convenient place

Administer 7 & 8 simultaneously, score separately.

7. Removes and replaces lid of screw-type jar

Jar placed on board anterior to child's midline at any location which accommodates child's attempts to grasp jar.

0. does not touch jar
1. places one or both hands on jar
2. unscrews and removes jar lid
3. replaces jar lid and screws it closed

8. Picks up raisin (or Cheerio), places in mouth with preferred hand

Raisin placed on board at any location which accommodates child's attempts to pick up raisin.

0. does not touch raisin
1. touches raisin with tips of fingers and/or thumb
2. picks up raisin and holds 3 sec
3. releases raisin in mouth
9. **Picks up pen, makes a mark**

Pen and 8-1/2 x 11" paper placed midline on board, pen tip pointing toward child.

0. does not grasp pen  
1. grasps pen with one or both hands  
2. grasps and lifts hand and/or pen clear of surface  
3. marks paper with pen

10. **Places dice in jar, one at a time, with preferred hand, in 30 sec**

Place dice and jar on board as indicated by paper guide immediately in front of child. Request child to place dice into jar, one at a time, using one hand, as fast as possible. If at end of time period child has picked up a die but not completed placing it in the jar give credit for that die.

0. does not place any dice in jar  
1. places one die  
2. places 2 to 5 dice  
3. places 6 dice

11. **Moves his/her wheelchair forward 45' in less than 20 sec**

Allow one practice trial to ensure child understands the task.

0. unable to move wheelchair forward  
1. moves wheelchair forward 10' in less than 60 sec  
2. moves wheelchair forward 45' in less than 60 sec  
3. moves wheelchair forward 45' in less than 20 sec

12. **Moves his/her wheelchair forward 10' along 8' wide corridor, turns right or left 90° and passes through 33" doorway**

Allow one practice trial to ensure child understands the task. Maximum of 60 seconds allowed for completion of the task.

0. does not move wheelchair forward 10' without bumping into walls  
1. moves wheelchair forward 10' but does not initiate a turn  
2. moves wheelchair forward 10' turns and passes through doorway with wall contact  
3. moves wheelchair forward 10', turns and passes freely through doorway

**TOTAL SCORE FUNCTION SECTION** (MAX. = 48)

Enter score on Page 1
Appendix 5   SPCM Guidelines (Draft 8)
(used in 1993 reliability study)
Seated Postural Control Measure (SPCM)  
Guidelines to Draft #8  May 1992

The purpose of this measure is to evaluate change in postural alignment and control in children who have been prescribed adaptive seating systems. It is intended that administration will take 30 minutes or less and will require little in the way of special equipment. All items are administered while the child is sitting. The measure may be administered while the child sits in a prescribed seating system or with any other means of seated support, other than manual support.

These guidelines were followed in the reliability study of Spring 1992. They provide definitions for completing the information on Page 1 of the measure and describe administration and scoring of the Alignment and Function Sections.

EQUIPMENT

1. Selection of toys to motivate the child as well as a specific small toy for grasp and release items. The small toy will consist of 2 Duplo blocks stuck together to form a block with dimensions of 2.5" x 1.25" x 1.5". Hooked Velcro is secured to the largest surface of the block.
2. Ruler - rigid yard or meter stick
3. Stopwatch
4. 2' x 2' positioning board = two layers of 'tenplast' or other heavy cardboard. A 1" wide strip of mat Velcro, marked at 1" intervals, is attached along the midline of the board to allow target object to be secured on the board
5. Layout guide. This is a sheet of 81/2" x 11" paper with a diagram on each side, enclosed in a clear plastic envelope. The first diagram has 2 lines running from the midpoint of the 11" border of the page. The lines form an angle of 120° and provide a guide for Item 4 of the Function Section. The diagram on the other side of the sheet is of 2 circles, 5" diameter, lying side by side. These circles are guides for Item 10 of the function Section.
6. Dice - 6, approximately 1/2" cubes
7. Pen - marker pen, approximately 1/2" diameter or adapted pen/pencil used by child
8. Raisins (or Cheerios, if deemed more safe for child)
9. Sheet of paper - 8 1/2" x 11"
10. Jar - 90 cc Urine Specimen jar, diameter = 2", height = 3"
11. Container - any open container (such as a bowl) with at least a 5 " diameter opening
12. Goniometer
13. Inclinometer (hardware store variety)
14. Flexible curve (e.g. Staedler Mars product, available in most stationary stores)
15. Bench with ethafoam or High Mat
16. Protractor made of clear acrylic. Size = 10 3/4" long x 5 1/4' radius x 1/4' thick, marked with the following angles on the right and left of the protractor: 5°, 15°, 20°, 25°, 30°, 35°, 40°, 45°, and 55°
Level of Sitting Scale

The seven levels of sitting ability are based on the amount of support required to maintain the sitting position and, for the children who can sit independently without support, the stability of the child while sitting.

**Test Conditions**
Child is in 'sitting position' at edge of a high mat or bench with feet **unsupported**.

**Definition of 'sitting position'**
- The child's hips and lower trunk can be flexed sufficiently so that the trunk (defined by a line joining T1 and sacrum) is inclined at least 60 degrees above the horizontal plane.
- The child's head is either neutral with respect to the trunk or flexed.
- The position can be maintained for a minimum of **30 seconds** with due regard for the safety and comfort of the child.

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>DESCRIPTOR</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unplaceable</td>
<td>Child cannot be placed or held by one person in sitting position</td>
</tr>
<tr>
<td>2</td>
<td>Supported from Head Downward</td>
<td>Child requires support of head, trunk and pelvis to maintain the sitting position</td>
</tr>
<tr>
<td>3</td>
<td>Supported from Shoulders or Trunk Downwards</td>
<td>Child requires support of trunk and pelvis to maintain sitting</td>
</tr>
<tr>
<td>4</td>
<td>Supported at Pelvis</td>
<td>Child requires support only at the pelvis to maintain sitting</td>
</tr>
<tr>
<td>5</td>
<td>Maintains Position, Does Not Move</td>
<td>Child maintains the sitting position independently if he/she does not move limbs or trunk</td>
</tr>
<tr>
<td>6</td>
<td>Shifts Trunk Forward, Re-erects</td>
<td>Child, without using hands for support, can incline the trunk at least 20° anterior to the vertical pane and return to the neutral (vertical) position</td>
</tr>
<tr>
<td>7</td>
<td>Shifts Trunk Laterally, Re-erects</td>
<td>Child, without using hands for support, can incline the trunk at least 20° to one or both sides of midline and return to the neutral position</td>
</tr>
</tbody>
</table>
'Cognitive Level'

Understands most instructions:
follows 75% of the instructions without prompting, visual or verbal cueing, or hand-over-hand demonstration

Understands few instructions:
follows less than 75% of instructions; or required prompting and/or visual or verbal cueing and/or hand-over-hand demonstration

'Cooperation Level'

Cooperates fully:
for 75% or more of the test items, child does not resist participation

Cooperates with prompting:
for 75% or more of the test items, the child can be encouraged to participate with verbal and/or visual and/or tactile stimulation

Uncooperative:
for 75% or more of the test items, child resists cooperation

Description of Seating System Used in Test

The extent of information entered in this section depends upon the needs of the test user. However, information about the orientation of the seating system used by the child is important and is described as follows:

Seat-to-back angle:
The angle between the planar surfaces (not the padded interface surfaces) of the seat and back. This angle may be measured with a goniometer or inclinometer.

Tilt-in-space:
The angle between the planar surface of the seat back and the vertical plane, e.g., the tilt-in-space when the seat back is in the vertical position is 0 degrees. The inclination of the seat back is best measured with an inclinometer.

ALIGNMENT SECTION

Administration

All items are administered while the child is sitting. The therapist may palpate bony reference points when observing alignment but should not provide manual support or correct the child's position after initial correct placement of the child in the seat.
Use of Protractor

The protractor is meant as a visual aid in determining angles for the alignment items (e.g., Item 5 - hip rotation, Item 11 - head anterior/posterior tilt). A goniometer can also be used, but the protractor was found to be easier to use.

Use of the Flexible Curve

The Curve is placed on the client's pelvis joining one ASIS to the other with the ends wrapped around to the back of the pelvis to hold the curve in place. This provides a visual cue when determining alignment angles. The position of the Curve needs to be checked frequently to ensure correct positioning over the ASIS's is maintained.

Position References

Positions of the axial skeleton (with the exception of trunk rotation) are described according to their orientation in space. Limb joint positions and trunk rotations are described according to joint angle using terminology of the American Academy of Orthopedic Surgeons.

Scoring

There are 22 alignment items listed in order of their observation from anterior, lateral and superior views. The posture of the axial skeleton is represented by 12 items and the limb positions by 10. There are 4 levels per item, with a score of 1 representing the normal erect sitting posture with approximately 90° angles at the hips, knees and ankles and scores of 2 to 4 representing mild, moderate and severe deviations from normal. The total score for the alignment section may range from 22 to 76.

Circle the score closest to the estimated observed angle. If the child frequently changes position, select the score estimated to be the most commonly sustained posture. If the estimation is exactly between two scores, select the score which reflects the worst posture. Note that limb joint positions may be asymmetrical and thus each limb may receive a different score.

Please note that categories for Item 11, head anterior/posterior tilt, have movement ranges unlike most other items. Usually the midpoint of the movement range in the 'normal' category is 0 (either horizontal or vertical). With Item 11, the movement range for the normal category is 15-24° with the midpoint at 20° anti-clockwise from the horizontal. When scoring this item, the range for 'mild' anterior tilt is from the horizontal (0°) to 14° above the horizontal (anti-clockwise). The range for 'moderate' anterior tilt is from 1° to 15° below the horizontal (clockwise). 'Severe' anterior tilt is 16° or more below the horizontal (clockwise).

Do not leave blanks; score all items. If it is impossible to test an item, enter '99' as the score.
FUNCTION SECTION

Administration

All items are administered with the child in a sitting position. If the seating system has adjustable tilt-in-space, tests should be conducted at the usual 'working' tilt assumed by the child.

A positioning board will be used for all test items which require reach, grasp, or manipulation of objects. The board (2'x2', made of light, fairly rigid material such as 'tenplast') will be held horizontally by the therapist at approximately the child's waist height (or higher if necessitated by the system). It may help the assessor to steady the board on a cushion placed on the child's lap or on armrests, if present. However, if the child's seating system includes a tray, the board should rest upon the tray at the inclination regularly used by the child. (Note: inclination of the tray is one reason for using Velcro to mark the target location and prevent the target object from slipping.)

Roughly 1 minute should be allowed for motivating a child and completing each item. If several attempts are made during this time, score the best attempt. Use verbal and gestural encouragement but no "hands on" assistance or support.

Definitions

'Arms length':
The distance from acromial angle to ulnar styloid process with arm passively outstretched maximally and flexed approximately 90° at the shoulder. When measuring from subject to target location, it is easiest to rest a rigid measuring stick on the board, then place a piece of sticky-backed Velcro no larger than 1/4" square at the measured location.

'Wheelchair':
A manual or power mobility system regularly used by child.

'Preferred hand':
The hand which appears to be used most frequently by the child.

Scoring

Enter scores for ALL items. Items not tested should be handled as follows:
If it is evident without testing that a child will score '1' on an item, enter the true score, i.e., '1'. For example, if the child does not possess an independent type mobility base, '1' would be the score for Function items 11 and 12. If an item cannot be tested for some temporary reason, enter '99' in the score column. Two examples of temporary reasons are: (1) child is independent in wheelchair mobility but wheelchair is unavailable at time of test; or, (2) arm is in a temporary cast, preventing the child from performing upper limb tasks as usual.