ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2016;■:■■■-■■■

ORIGINAL RESEARCH

Perspectives on Postural Control Dysfunction to Inform Future Research: A Delphi Study for Children With Cerebral Palsy

Rosalee Dewar, BPhty,[a] Andrew P. Claus, PhD,[a] Kylie Tucker, PhD,[b] Leanne Marie Johnston, PhD[a]

From the [a]School of Health and Rehabilitation Sciences, and the [b]School of Biomedical Sciences, The University of Queensland, Brisbane, Australia.

Abstract

Objective: To identify whether consensus can be achieved in how clinicians and researchers define, describe, assess, and treat postural control dysfunction in children with cerebral palsy (CP).

Design: Delphi study with 3 iterative rounds.

Setting: Electronic survey.

Participants: Researchers and/or clinicians (N=43) from 7 countries with a mean ± SD of 20±11 years of experience working with children with CP participated. Participants included authors of published works on postural control in CP (identified from a recent systematic review), members of the Australasian Academy of CP and Developmental Medicine, and 2 major Australian rehabilitation providers.

Interventions: Not applicable.

Main Outcome Measures: The Delphi study consisted of 3 iterative rounds of surveys. In Round 1, respondents answered open-ended questions regarding their views on (1) definition items for postural control, (2) theoretical frameworks, (3) methods for assessment, and (4) interventions for postural control dysfunction in children with CP. Rounds 2 and 3 were made up of items generated by participants in Round 1 and combined with items identified from the literature. Participants indicated their level of agreement for each item on a 7-point Likert scale. Threshold for consensus was ≥85% agreement.

Results: Of 306 items generated, 174 reached consensus by Round 3. Most postural control definition items (90%) achieved consensus. Two theoretical frameworks (14%) reached consensus. Less than half (42%) of assessment items reached consensus. More individual assessment items (89%) reached consensus than multi-item tools (4%). Just over half (61%) of the items generated for interventions reached consensus.

Conclusion: Consensus was achieved for a postural control definition. However, substantial research is needed to establish a comprehensive, postural control−specific framework and suite of assessments. These would provide a foundation to improve intervention selection and dosage.

Archives of Physical Medicine and Rehabilitation 2016;■:■■■-■■■

Children with cerebral palsy (CP) experience significant activity limitations that are associated with impairments in the development of movement and posture.[1] This widely understood and accepted definition of CP is associated with a great deal of research on movement dysfunction devoted to classification,[2-4] assessment,[5,6] and treatment.[7] By comparison, however, there has been limited research on postural control dysfunction devoted to classification, assessment,[8,9] or treatment.[10]

The control of posture in children with CP has been variably defined in the literature. For example, authors have used terms such as postural control,[9,11] balance function,[8,12,13] postural stability,[14,15] static balance,[16] and dynamic stability.[17] Although these appear to refer to elements of the same construct, in order to improve consistency in approach to assessment and treatment, it is desirable to have an agreed definition for the overarching construct of postural control and its elements. An agreed

Presented to the Australasian Academy of Cerebral Palsy and Developmental Medicine, March 30 to April 2, 2016, Adelaide, Australia.

Supported by a Career Development Grant awarded by the Research Foundation, Cerebral Palsy Alliance (grant no. PG4114) that allowed PhD funding support through the Children's Motor Control Research Collaboration.

Disclosures: none.

0003-9993/16/$36 - see front matter © 2016 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2016.07.021

theoretical framework would help to describe the relationships between elements and the overarching definition, for shared understanding and communication about the control of posture. Literature involving children with CP lacks an explicit framework for postural control. Literature for adults with neurologic impairment has used frameworks for postural control[18-20] (eg, systems theory applied to postural control), but these have not been validated for children with or without CP.

Without consensus on the definition or theoretical framework for postural control, a consensus for the most valid and reliable assessments is also lacking. Two systematic reviews of clinical[8] and laboratory-based[9] postural control assessments for children with CP (both published in 2013) identified 3 laboratory tools and 22 different clinical assessments of postural control used in this population. Results support validity and reliability of laboratory tools such as forceplates, electromyography, and kinematic analysis.[9] However, clinical assessment measures had limited psychometric evidence, and the psychometrics for assessment batteries that differentiate the components of postural control remain to be examined.[8] The extent to which recommended assessments have been translated into clinical practice is unknown. Furthermore, the systematic review[10] of postural control interventions for children with CP in 2015 identified that clinical assessment measures have rarely been used as outcome measures for clinical trials. An agreed definition and framework for postural control is needed to underpin development of valid assessments.

A lack of clarity around definitions, frameworks, and assessment for postural control means that caution is needed in the interpretation of results of intervention trials for postural control. Our systematic review[10] on interventions identified 5 approaches that achieved a moderate level of evidence for improving some aspects of postural control in children with CP. However, this review did not include interventions that did not report a specific measure of postural control, and it may have underestimated the scope of improvements afforded by other interventions that included individual postural control assessment items rather than a full test battery. Postural control−specific assessment items are needed in order to determine the efficacy of clinical interventions to improve postural control.

One way of achieving consensus is via use of a Delphi study. A Delphi study is a mixed-methods research tool that uses surveys in 3 progressive rounds.[21] The Delphi study has been used to gather expert opinion of professionals knowledgeable in CP, to inform clinical practice and enhance decisions regarding future research directions for this population.[2,22,23] The Delphi, particularly when distributed electronically, has 2 benefits over consensus meetings: (1) it allows access to a wider scope of participants who do not need to be physically in the same place; and (2) it avoids any adversarial group dynamics.[24] The validity of the Delphi is improved when used in conjunction with current literature.[21] Therefore, a Delphi study based on current literature in conjunction with expert opinion is an appropriate choice to develop consensus on postural control definitions, frameworks, assessment, and interventions. Furthermore, this Delphi will help to focus future research in this field, which will then inform clinical guidelines that can advise on intervention approaches.

Therefore, the aim of this study was to collect and synthesize perspectives about postural control from clinicians and researchers who have experience with children with CP. Specifically, the aim was to seek a consensus about (1) *definitions* of postural control; (2) *frameworks* used to describe postural control and guide development of the construct and content of assessments and interventions; (3) *assessments* for postural control; and (4) *interventions* used to treat postural control dysfunction in children with CP.

List of abbreviations:

AusACPDM	**Australasian Academy of Cerebral Palsy and Developmental Medicine**
CP	**cerebral palsy**
CPL	**Cerebral Palsy League**
ICF	***International Classification of Functioning, Disability and Health***
NHMRC	**National Health and Medical Research Council**

Methods

A Delphi study, which included 3 rounds of surveys sent electronically, was used to gather and synthesize expert opinion of clinicians and researchers. Ethical approval was gained from the National Health and Medical Research Council (NHMRC)-registered Human Research Ethics Committees of the Cerebral Palsy League (CPL) (Queensland) (NHMRC EC00417), The University of Queensland (NHMRC EC00179), and an expedited approval (waiver) was granted by the Cerebral Palsy Alliance (NHMRC EC00402).

Gatekeeper approval was obtained to distribute the surveys via e-mail to (1) members from the Australasian Academy of Cerebral Palsy and Developmental Medicine (AusACPDM) from the president on behalf of the AusACPDM board (pediatric rehabilitation professionals from the Asia-Pacific region including Australia, New Zealand, and Asia); (2) the Allied Health Manager of the CPL, who distributed the surveys to clinicians and researchers working in Queensland, Australia; and (3) the research manager of the Cerebral Palsy Alliance, who distributed the surveys to clinicians and researchers working in New South Wales, Australia.

Participants

The recruitment strategy was based on the recommendation from De Villiers et al,[25(p639)] where the purpose of using a Delphi approach is to "generate expert opinion in an anonymous fashion" where an "expert panel is identified and invited to provide opinions." On this basis, an expert panel was obtained by seeking clinicians and/or researchers with both (1) suitable professional qualifications required for diagnosing and/or managing postural control dysfunction in children with CP (ie, physiotherapists, occupational therapists, speech pathologists, pediatricians, rehabilitation physicians, and neurologists who are clinicians and researchers); and (2) reported experience in assessment or treatment of postural control dysfunction in children with CP (ie, the study information form requested that participants had past experience in assessing and/or treating postural control dysfunction in children with CP before taking part in the study, thereby confirming knowledge of postural control dysfunction in this population).

Health professionals were contacted from (1) the CPL and CP Alliance through the organization's representative; (2) members of the AusACPDM (nonmedical AusACPDM members, eg, lawyers or parents, were not contacted); and (3) authors of research articles about postural control who were identified in recent systematic reviews[8-10] and who have published contact details. Potential participants numbered approximately 711, based on the number of invitations disseminated (fig 1). Some overlap may have occurred between invitations to health professionals who were members of the AusACPDM and staff of the CPL and CP Alliance.

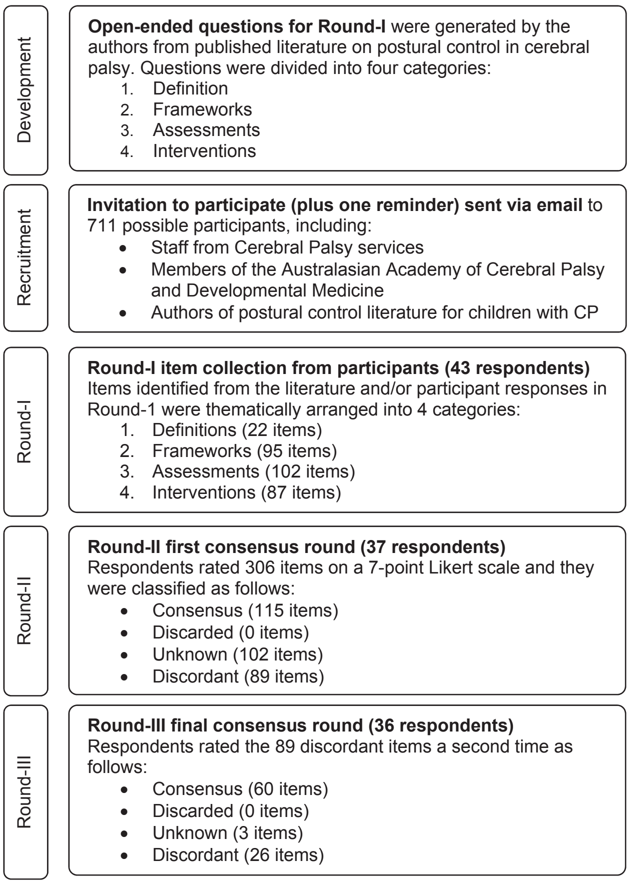


Fig 1 Delphi study flow diagram.

Data collection and analysis

Three rounds of surveys were used, which is considered adequate to achieve an acceptable degree of consensus.[25] Consistent with recent recommendations to improve methodological integrity and rigor of Delphi studies,[21,24] the procedures are presented in detail and include qualitative and quantitative assessments to inform the construction of each survey round.[21]

Round 1 (item generation) of the Delphi was distributed via e-mail to potential participants. The e-mail included an invitation to participate and an electronic link to the first of the online surveys, which included the participant information sheet and consent forms. One reminder e-mail was sent 7 to 9 days after the first e-mail to all nonresponders. Respondents who submitted Round 1 also gave consent to participate in subsequent rounds. Round 1 contained open-ended questions constructed by the authors (box 1) based on theoretical principles of postural control and systematic reviews of postural control assessments,[8,9] interventions,[10] and approaches.[10] The questions sought responses for postural control (1) definitions; (2) framework for development, assessment, and intervention; (3) assessments; and (4) interventions for children with CP. The first author (R.D.) performed content analysis of the responses to identify individual items to be included in Round 2. This analysis was reviewed and confirmed by the other authors. These items were combined with those identified in the systematic reviews[8-10] to form the Round 2 item list. Round 2 (week 8) and 3 (week 20 after initial mail out) were subsequently e-mailed to all Round 1 respondents (see fig 1).

In Round 2, the first consensus round, respondents ranked each item for agreement on a 7-point Likert scale (1, strongly disagree; 2, moderately disagree; 3, slightly disagree; 4, not sure or no comment; 5, slightly agree; 6, moderately agree; 7, strongly agree). For analysis of Round 2 data, each item was classified into 4 response categories:

1. *Consensus:* An item reached consensus if ≥85% of respondents agreed "strongly," "moderately," or "slightly."[22,25]
2. *Discarded:* An item was discarded if ≥85% of respondents chose to disagree "strongly," "moderately," or "slightly."
3. *Unknown:* Items that >15% of respondents selected "not sure" or "no comment" (ie, responses could not achieve ≥85% agreement or disagreement).
4. *Discordant:* For all of these items, respondents could not agree; therefore, items were retained and then re-presented without change in Round 3 (see fig 1).

For Round 3 data collection, the final consensus round, each item that was classified as discordant in Round 2 was re-presented to all respondents to be reranked for agreement on the same 7-point Likert scale. In this round, respondents were first shown a list of items that reached consensus and a list of items that were classified as unknown in Round 2. Then, they were shown graphs of Round 2 results for the 89 discordant items. Respondents were then asked to rerank the 89 discordant items.

At the completion of Round 3 of the Delphi, the ordinal Likert scale data were used to calculate the median, interquartile range, minimum and maximum responses for each item. These data were not used to determine consensus, but demonstrate the central tendency and distribution of responses, including unknown items.

Results

Participants

A total of 43 participants responded to the original invitation. Participants identified themselves as currently living in Australia (79.1%, n=34), South Africa (4.7%, n=2), United Arab Emirates (4.7%, n=2), United States (4.7%, n=2), the Netherlands (2.3%, n=1), New Zealand (2.3%, n=1), and United Kingdom (2.3% n=1). Respondents included physiotherapists (65.1% n=28) and occupational therapists (16.3% n=7) as well as 6 other different health professions (table 1). These data indicate a predominance of respondents being physiotherapists, which is consistent with the overall clinical role played by physiotherapists in managing postural control deficits in children with CP, but also the specific role played by other disciplines in assessing and treating specific postural control for certain functions such as oral motor or fine motor performance. Respondents had a mean ± SD of 20±11 years of experience working with children with CP (range, 2–55y). Most participants (n=26, 60%) described their employment role as clinical, with 19% (n=8) identifying as researchers and 21% (n=9) as a combination of the two. These data indicate a spread of respondents across clinical and nonclinical roles including experts in both fields. Thirty-seven people responded to Round 2 (86% retention) and 36 (83% retention) in Round 3.

Round 1: Item generation

Round 1 generated a total of 306 unique items. The 306 items were placed into 4 categories: (1) *Definitions:* 22 items relating to the definition of postural control; (2) *Frameworks:* 95 items that

Box 1 Open-ended questions presented to participants in Delphi Round 1

Definitions of Postural Control
1. In your own words how would you define postural control?

Frameworks for Postural Control
2. Are there any theoretical frameworks or guiding principles that you think describe postural control well? eg, a framework includes concepts and theories that you may base your assessment and treatment of postural control dysfunction. If you do not use a particular framework respond "none."
3. Are there any books, articles, or authors that you refer to when thinking about postural control?
4. What factors relating to the INDIVIDUAL do you believe are important in postural control function or dysfunction? eg, body structures, functions, systems, processes, attributes.
5. What factors relating to a TASK do you believe are important in postural control function or dysfunction? ie, WHAT the person is doing, HOW they are doing it.
6. What factors relating to the ENVIRONMENT do you believe are important in postural control function or dysfunction? ie, WHERE the person is doing a task, things around the person.

Assessments of Postural Control
7. How do you ASSESS postural control in INFANTS with CP (aged 0—1 years)? eg, assessment items, tests, observations.
8. How do you ASSESS postural control in YOUNG CHILDREN with CP (aged 1—5 years)? eg, assessment items, tests, observations. If same as above, write "as above."
9. How do you ASSESS postural control in PRIMARY SCHOOL CHILDREN with CP (aged 5—13 years)? eg, assessment items, tests, observations. If same as above, write "as above."
10. How do you ASSESS postural control in YOUNG PEOPLE with CP (aged 13—22 years)? eg, assessment items, tests, observations. If same as above, write "as above."
11. How would you describe the relationship between postural control and movement control? eg, do you consider/assess/treat these factors separately or together? How do you do this?

Interventions for postural control
12. What EXERCISE STRATEGIES do you consider effective in treating postural control dysfunction? eg, exercises or active therapy approaches. Please indicate which ages are relevant and how much is needed to be effective.
13. What OTHER INTERVENTIONS do you consider effective in treating postural control? eg, equipment, medication, surgery. Please indicate which ages and how much is needed to be effective.
14. Do you recommend any MAINSTREAM ACTIVITIES for children with CP who have postural control difficulties? eg, sports or recreation activities. Please indicate which ages and how much is needed to be effective.
15. Are there any strategies or activities that are effective that you find it difficult to provide? Please indicate if this is due to inadequate (1) Information/skills, (2) funding/hours, (3) equipment/environment.

described theoretical frameworks, clinical approaches, and factors influencing postural control; (3) *Assessments:* 102 items that may be used for assessment of postural control in children with CP; and (4) *Interventions:* 87 items that may be used as an intervention for improving postural control in children with CP (see fig 1).

Round 2: First consensus round

In Round 2, the 306 items were e-mailed to respondents for ranking (7-point Likert scale) within the 4 categories determined in Round 1. The 22 items identified for category 1 (Definitions) were divided into 3 subcategories (1a, 1b, 1c) to reflect that many respondents had defined postural control in (1a) general terms (14 items), as well as more specific definitions for (1b) static postural control (4 items) or (1c) dynamic postural control (4 items).

The 95 items identified for category 2 (Frameworks) included theoretical frameworks (eg, systems theory) and clinical approaches (eg, motor learning or task-oriented approach). For Round 2, respondents were asked to rank each item as it related to the subcategories (2a) development (12 items), (2b) assessment (12 items), and (2c) treatment of postural control (12 items). For Round 2, respondents were also asked to rank factors that they believed were important in achieving effective postural control or problematic in postural control dysfunction. These factors were divided into subcategories relating to (2d) the individual (28 items), (2e) the task (13 items), and (2f) the environment (18 items).

The 102 items identified for category 3 (Assessment) were divided into 4 subcategories for Round 2: (3a) assessment batteries (47 items; eg, Berg Balance Scale); (3b) individual items (31 items; eg, single-leg stance); (3c) laboratory tools or measures (10 items; eg, electromyography); and (3d) the relationship between assessment of postural control and movement control (14 items; eg, treat and assess separately and together).

The 87 items identified in category 4 (Intervention) were divided into 4 subcategories for Round 2: (4a) therapeutic exercises or activities purported to treat postural control dysfunction (29 items; eg, treadmill training); (4b) dose of interventions highlighted in 4a (9 items); (4c) nonexercise interventions that may have a role in managing postural control dysfunction (16 items; eg, surgery); and (4d) mainstream activities that may support the development or maintenance of postural control in children with CP (33 items; eg, yoga).

From the 306 items included in Round 2, 115 items reached consensus. A further 102 items were removed because they reached the threshold for "unknown." Responses to the remaining 89 items were discordant, so these were re-presented to participants in Round 3 (see fig 1).

Table 1 Participant characteristics

Characteristics	n	%
Current employment role(s)*		
Clinical	35	81
Research	13	30
Teaching	3	7
Management	3	7
Occupation		
Physiotherapist	28	65
Occupational therapist	7	16
Researcher	2	5
Pediatrician	1	2
Speech pathologist	2	5
General practitioner	1	2
Orthotist	1	2
Rehabilitation physician	1	2
Country		
Australia	34	79
South Africa	2	5
Netherlands	1	2
New Zealand	1	2
United Arab Emirates	2	5
United Kingdom	1	2
United States	2	5
Years worked with CP		
0—4	3	7
5—9	6	14
10—19	10	23
20—39	22	51
40—49	1	2
50+	1	2
Highest qualification		
PhD	12	28
MD	1	2
Masters	10	23
Postgraduate diploma	8	16
Bachelors degree	12	28
Diploma in physiotherapy	1	2

* Some participants reported multiple roles.

Round 3: Final consensus round

In Round 3, respondents were asked to rerank the 89 discordant items. Final outcomes are documented in figure 2 (Definitions), and appendix 1 (Frameworks), appendix 2 (Assessments), and appendix 3 (Treatments). Round 3 identified a further 60 consensus items, for a total of 175 consensus items, including 19 definition, 60 framework, 43 assessment, and 53 intervention items. Round 3 also identified a further 3 unknown items, and 26 items remained discordant, for a total of 131 items that did not reach consensus, including 105 unknown (27 framework, 48 assessment, and 30 intervention items) and 26 discordant items.

Discussion

This study identified health professionals' perspectives on postural control definitions, theoretical frameworks, assessments, and interventions for children with CP that underpin current research and clinical practice. The Delphi process generated a consensus-led definition of postural control from a short list of generated items, which had a high rate of agreement among the participants. Much higher numbers of items were generated for the other 3 categories. However, only 2 items in the theoretical frameworks or approaches subcategory reached consensus. Less than half the items in the assessments category reached consensus. Most of these were individual assessment items and not multi-item tools. Just over half of the items generated for interventions reached consensus. These results indicate that theoretical frameworks and assessments are areas with the greatest knowledge gaps, and research activities are required.

The consensus definition items for postural control included "control of the body's position in space for postural orientation and postural stab," which is consistent with the definition suggested by Shumway-Cook and Woollacott[18] and work by Massion.[26] The subelement "postural stability" was agreed to be equivalent to "balance." Consensus was also reached for the subelement of postural orientation, which was agreed to be "the relationship of the body segments to each other, to the task, and to the environment."[18] Participants considered it important to differentiate control of orientation and stability/balance with reference to whether the child's base of support was static or moving; that is, "static tasks require the control of orientation and stability when the base of support does not change," and "dynamic tasks require the control of postural orientation and stability when the base of support is changing." Participants also agreed to some additional definitions of specific postural control strategies used to control orientation and stability during static and dynamic tasks—for example, the ability to "sustain" balance in a body position versus "protecting" oneself by taking a step to prevent a fall. Further work is required to refine the statements with consistent language and to link the statements into a model of postural control at the activity level of the *International Classification of Functioning, Disability and Health* (ICF). This would provide theoretical foundation for assessment and treatment choices for children with CP.

Theoretical frameworks and clinical approaches demonstrated limited consensus because most items proposed by participants in Round 1 and/or identified in the literature were either not known or not understood by respondents. One framework, the "motor learning or task-oriented approach," reached consensus for frameworks that underpin development, and an additional framework, the ICF framework, reached consensus for frameworks that underpin assessment and intervention of postural control in CP. However, both are general frameworks used to describe motor function and/or global functional performance that are not specific to postural control. Partial support was gained for 1 additional framework, the "systems theory," which has sound theoretical support in the postural control literature involving adults with neurologic conditions.[18-20] This theory describes 7 components contributing to postural control at the body functions and structures level of the ICF. Although this theory gained support from many participants (eg, 35.1% agree, 43.2% strongly agree), with only 1 disagree rating, it did not reach consensus in the context of assessing and treating children with CP. The main reason for this was that 21.6% of respondents indicated they were unfamiliar with the theory, perhaps because of its use with research on adults. Further work is required to develop a postural control framework to underpin assessment and treatment of children with CP that is consistent with the elements of the systems theory, task-oriented approaches, and the ICF framework.

The Delphi process showed limited consensus for postural control assessments that are valid and reliable for children with CP. This was due mostly to a lack of certainty about whether a tool

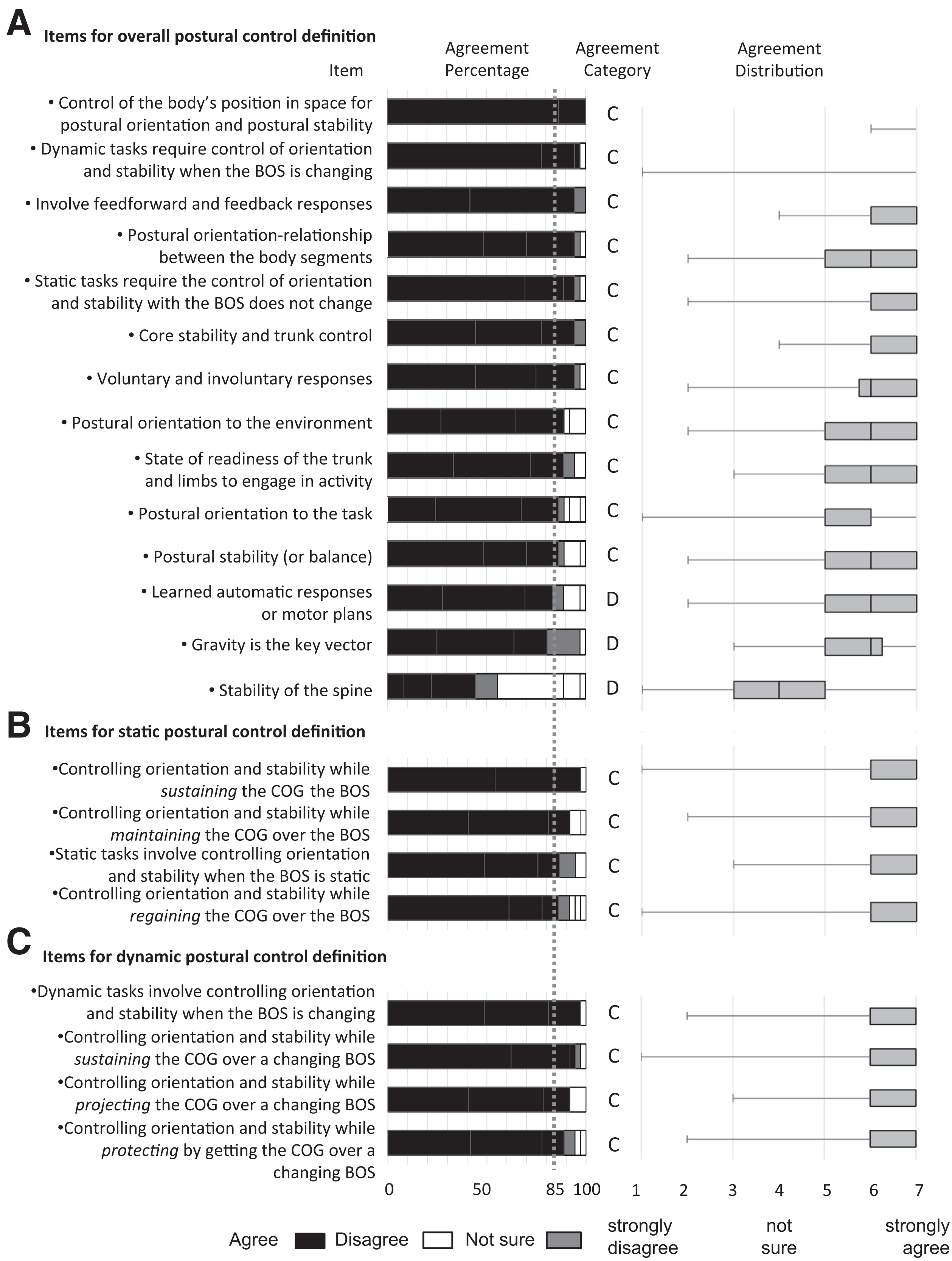


Fig 2 (A) Overall, (B) static, and (C) dynamic postural control definitions. Presented according to agreement percentage (85% threshold), agreement category (C, consensus; D, discordant), and agreement distribution (box and whisker plots with boxes representing the median and interquartile range, and whiskers representing the maximum and minimum values). Abbreviations: BOS, base of support; COG, center of gravity.

actually assessed postural control (n=43 unknown; 91%), rather than a lack of agreement regarding a tool (n=2 discordant; 4%). Two multi-item tools reached consensus for assessment of postural control in children with CP: the Gross Motor Function Measure and the Pediatric Evaluation of Disability Inventory. However, these require some consideration as to whether they objectively measure the construct of postural control. Both tools are well-established assessments for use in children with CP[6,27]; however, neither was included in a recent systemic review[8] of clinical tools to assess balance in children and adults with CP. There is no doubt that each tool assesses movements that require a range of postural control strategies; however, the way the items are evaluated measures gross motor abilities and not specifically postural control performance. For example, single-leg stance on the Gross Motor Function Measure tool is evaluated in terms of whether a child can or cannot perform this gross motor activity, rather than whether the child demonstrates adequate weight shift onto 1 leg, or positive support on the standing leg. Thus, at this time, consensus has not been achieved on an assessment to measure postural control skills exhibited by children with CP.

Other than these multi-item tools, many individual postural control assessment items reached consensus (n=26 consensus; 84%). When considered against the construct of postural control, most of these did provide measures specifically for postural control. Thus, these items could be collated into a postural control assessment battery for children with CP. However, this task is reliant on developing a valid postural control framework to provide a rationale for selecting these items for this population. It is apparent that the framework, or frameworks, would need to accommodate items at the ICF domain body structures and functions, similar to the systems theory, but also postural control strategies at the ICF activity level.

Consensus was reached for over half of the therapeutic exercise interventions proposed to improve postural control (n=16 consensus; 55%). These interventions were supported by findings of a recent systematic review[10] on exercise interventions for postural control dysfunction in children with CP; however, many new interventions not included in the review also reached consensus. One of the aims of the current Delphi was to identify whether clinicians were using any interventions for postural control not included in this recent review. There may be some interventions that clinicians consider effective in this population but lack evidence because of poor definitions, frameworks, and assessment. A complete list of interventions generated is contained within appendix 3, with consensus status reported.

Currently, more than 15% of participants classified the remaining therapeutic exercise interventions as unknown, indicating they were unsure of the nature or effectiveness of those interventions. There was no ideal intervention recommended. Instead, respondents supported individually tailoring the selection of interventions—for example, "I think any treatment has to be tailored to the specific individual"; "Which treatments might help very much depend on what the problems are"; "It depends on what element is causing dysfunction." Very few respondents commented on the dose of supported interventions. Those who did respond declined to state a specific dose, instead indicating that dose should depend on the type of intervention, and the type and severity of postural control dysfunction experienced by each child. Further, that during an intervention, the effect must be measured individually for each child. The combination of therapeutic exercise with nonexercise interventions (eg, botulinum toxin or surgery) and a transition to mainstream activities (eg, Pilates) was also unclear. These findings are consistent with recommendations of the recent systematic review[10] on treatment interventions and highlight the importance of establishing appropriate tools to assess and profile postural control deficits, as well as further research into the dose and responsiveness for therapeutic interventions and mainstream activities.

Study limitations

All efforts were made to ensure the methodological rigor of this Delphi. We invited participation of authors of all articles from recent systematic reviews on postural control in CP. These authors that responded to this invitation reside in 7 different countries. In addition, clinicians were recruited from 2 Australian clinical services and an Australasian professional association. Although Australasian clinicians have access to the international literature, we acknowledge that the recruitment method produced a predominantly Australasian perspective. It is possible that future studies will provide additional information from surveying the perspectives of clinicians from other countries. These results offer a cross-section of opinion at this time, for this particular group, and may be used to inform discussion and future research directions.[21]

Conclusions

A Delphi study has been completed that has identified perspectives of clinicians and researchers regarding postural control definitions, frameworks, assessments, and interventions for children with CP. Electronic Delphi distribution enabled involvement of a large number of participants simultaneously, to achieve a cross-section of opinion and a considered consensus on current practice. Consensus exists on the definition of postural control as it relates to children with CP. However, substantial research is required to establish postural control–specific theoretical frameworks and assessments and translate this research into clinical practice, in order for these items to achieve >85% consensus. Once these elements have been established, intervention research can follow to improve knowledge regarding specific intervention selection and dosage. Specifically targeted knowledge translation strategies must accompany each element of this work to ensure translation of evidence into practice.

Keywords

Cerebral palsy; Delphi technique; Postural balance; Rehabilitation

Corresponding author

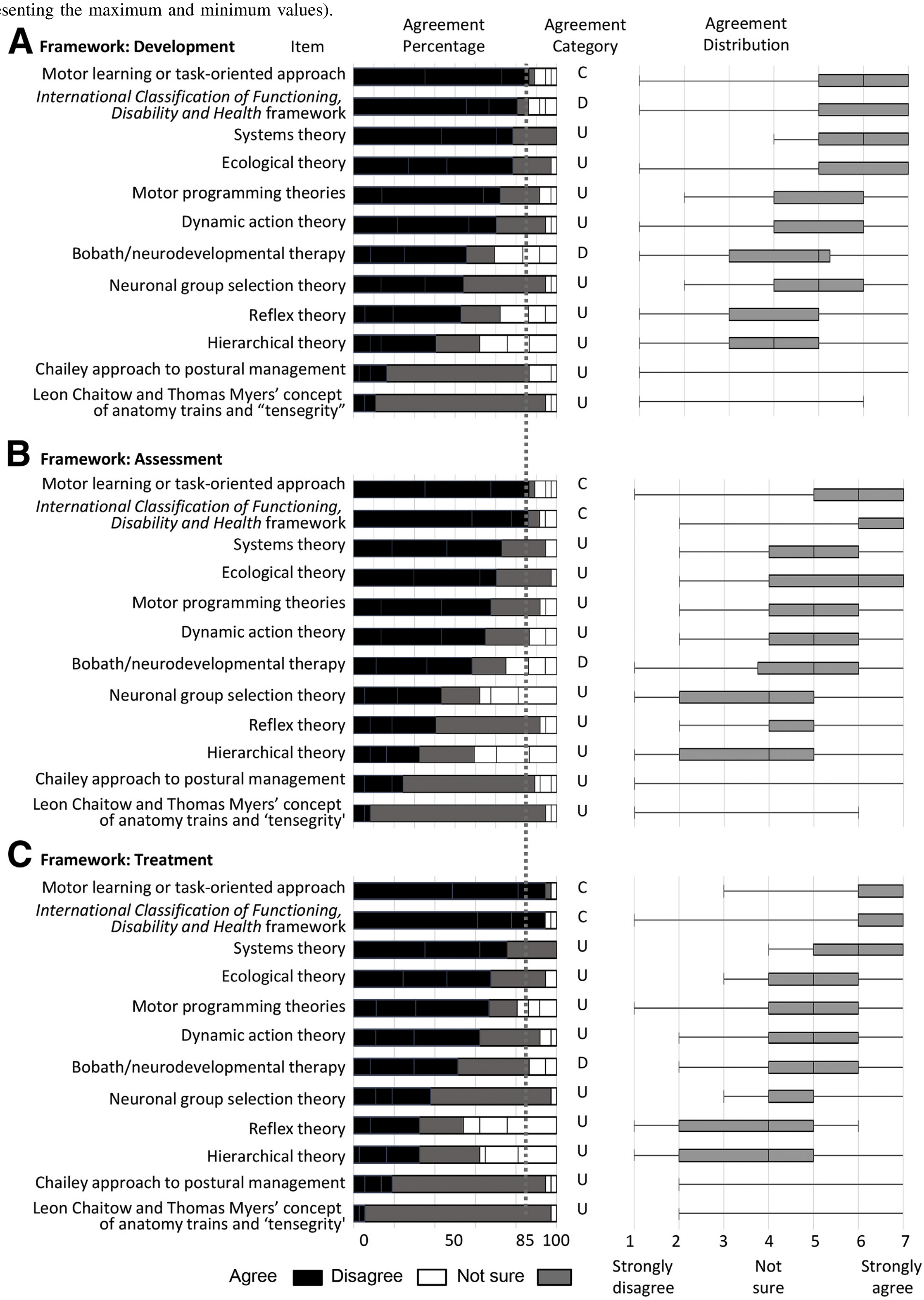
Rosalee Dewar, BPhty (Hons), School of Health and Rehabilitation Sciences, The University of Queensland, Brisbane QLD 4072, Australia. *E-mail address:* rosalee.sheather@uq.net.au.

Acknowledgments

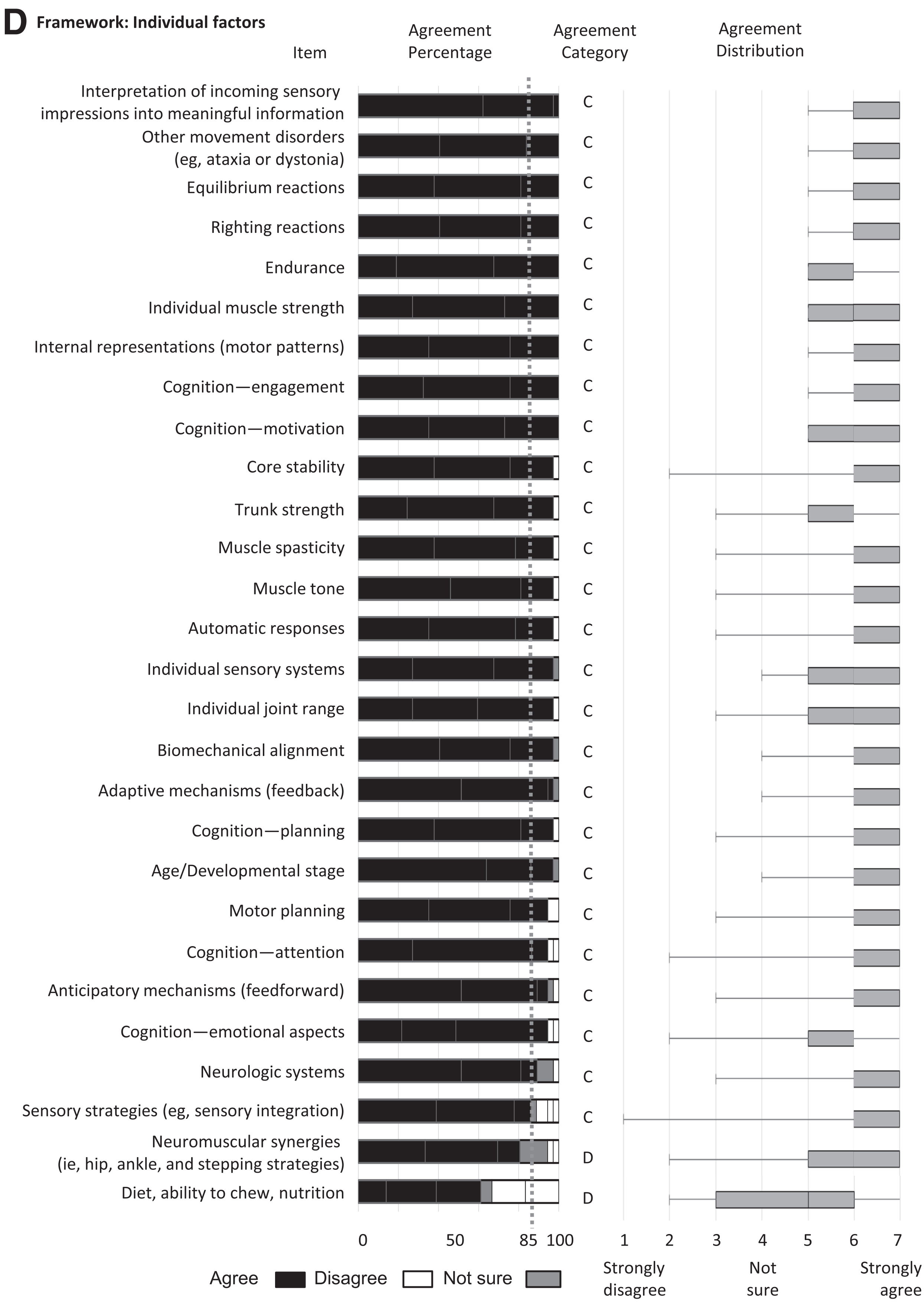
We thank the members of the AusACPDM, staff of the CPL (Queensland) and Cerebral Palsy Alliance (New South Wales), and the authors of published works on postural control research in CP for their valuable responses to this Delphi.

Appendix 1 Postural Control Frameworks

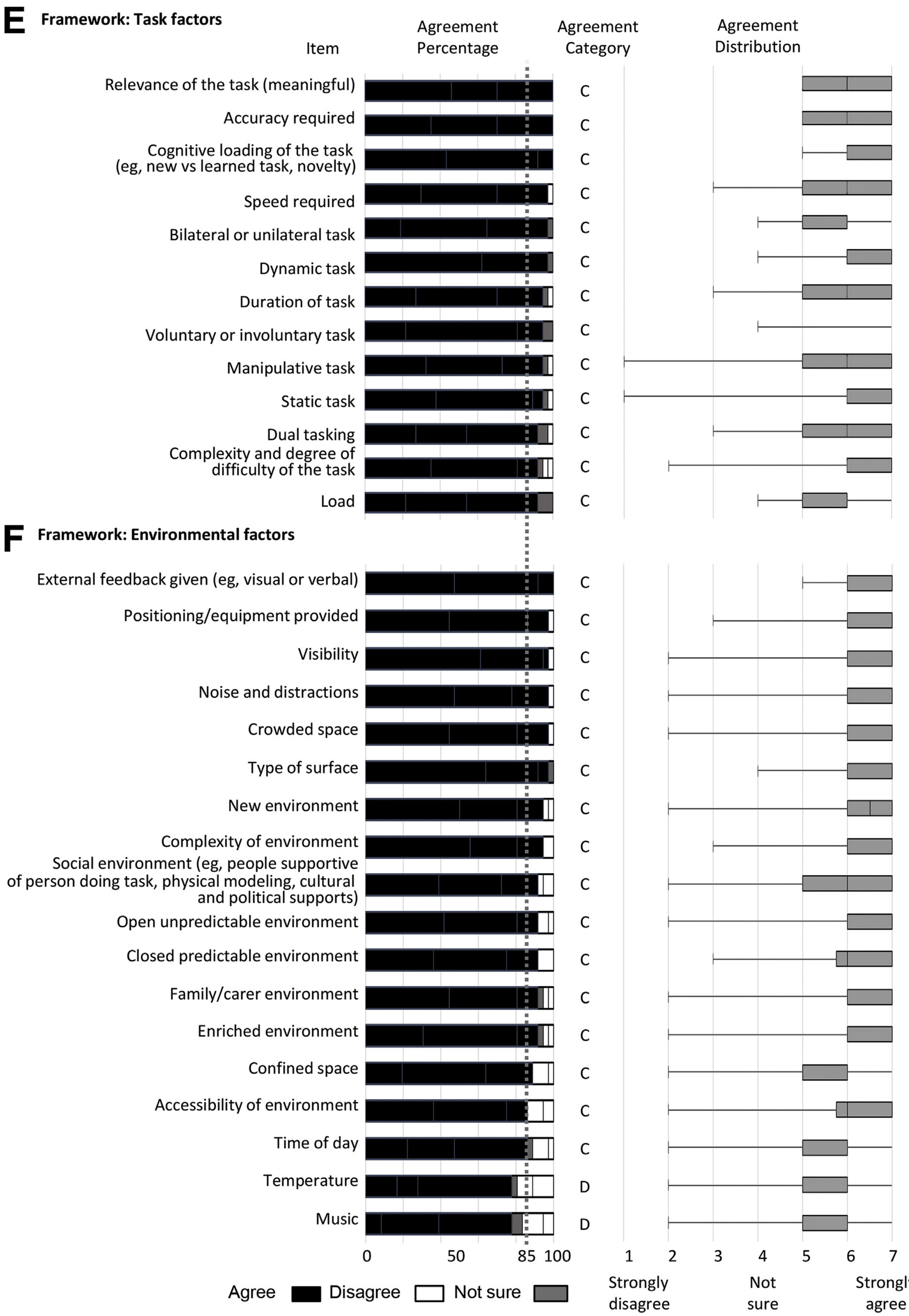
Postural control frameworks for (A) development, (B) assessment, (C) treatment, (D) individual factors, (E) task factors, and (F) environmental factors, presented according to agreement percentage (85% threshold), agreement category (C, consensus; D, discordant; U, unknown), and agreement distribution (box and whisker plots with boxes representing the median and interquartile range, and whiskers representing the maximum and minimum values).



Appendix 1 *Continued*

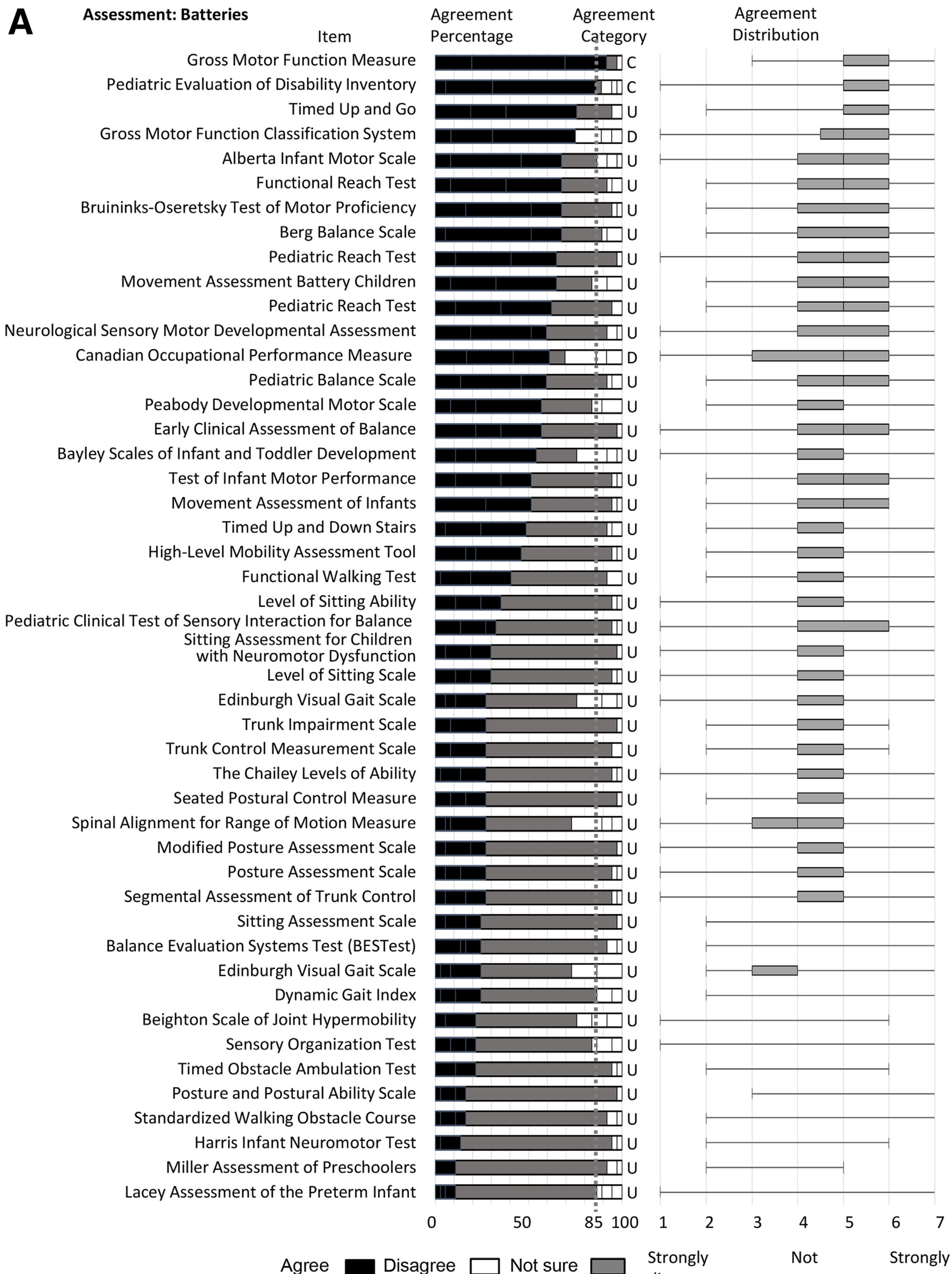


Appendix 1 *Continued*

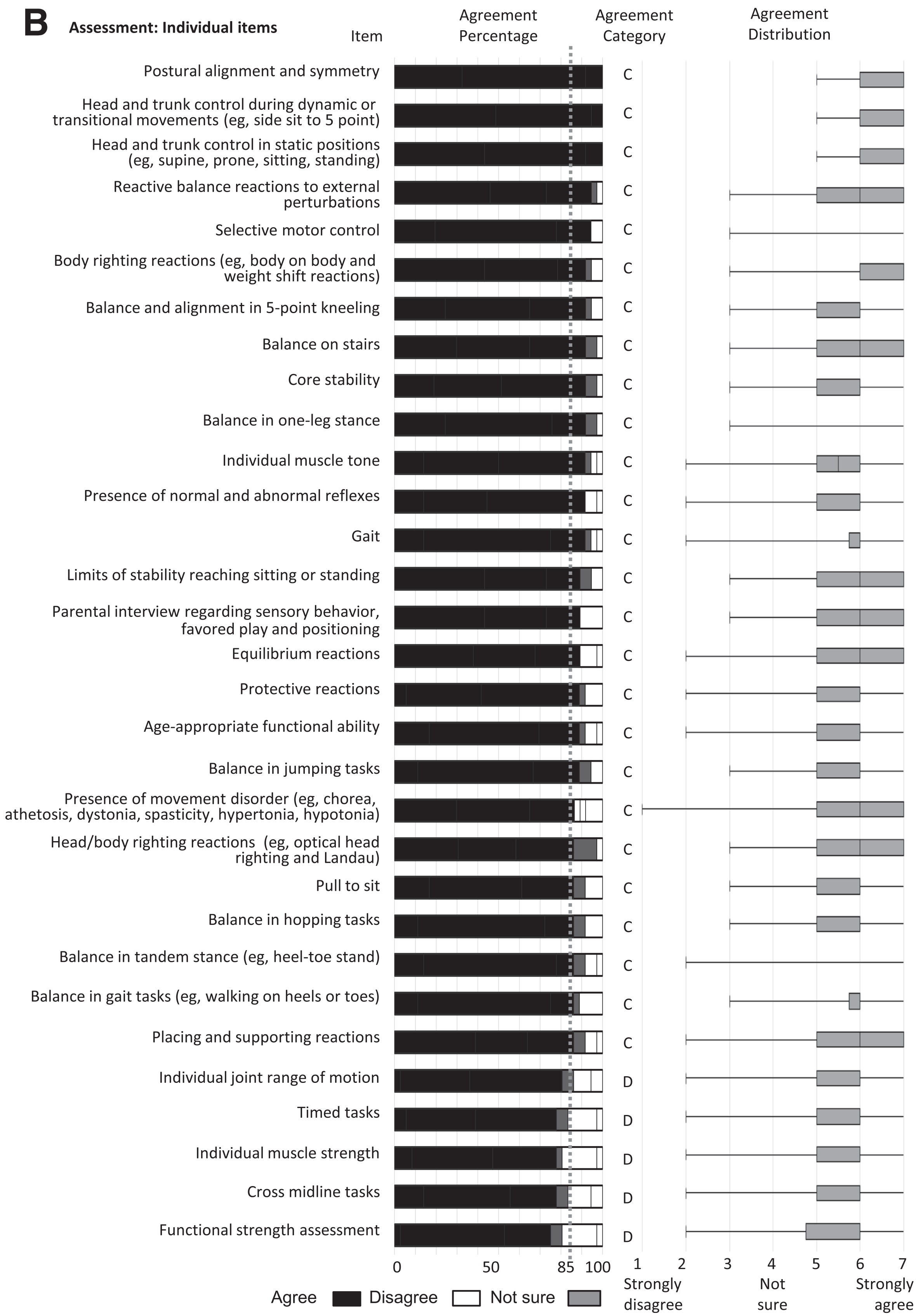


Appendix 2 Postural Control Assessments

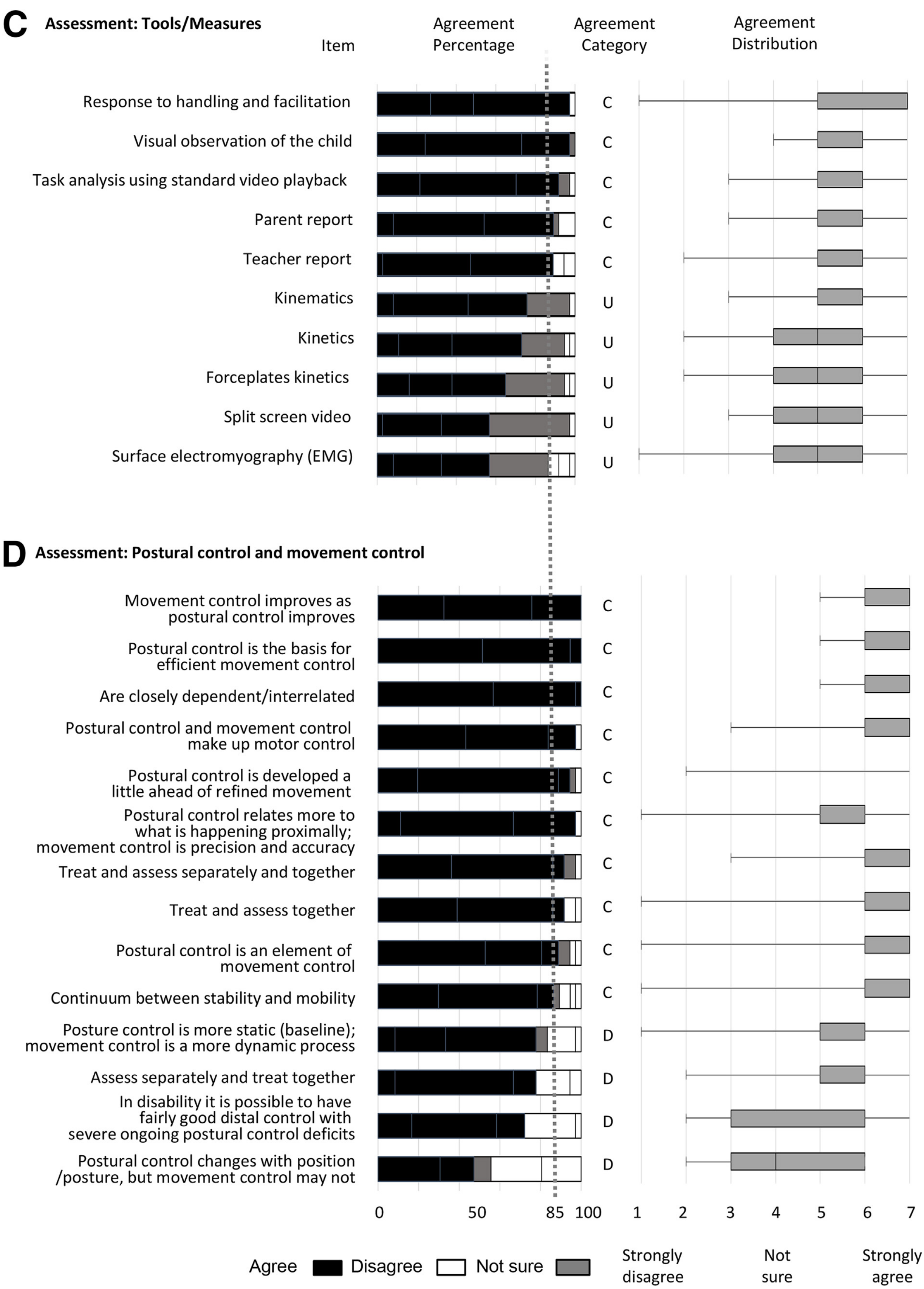
Postural control assessments for (A) batteries, (B) individual items, (C) tools/measures, and (D) postural control and movement control, presented according to agreement percentage (85% threshold), agreement category (C, consensus; D, discordant; U, unknown), and agreement distribution (box and whisker plots with boxes representing the median and interquartile range, and whiskers representing the maximum and minimum values).



Appendix 2 *Continued*

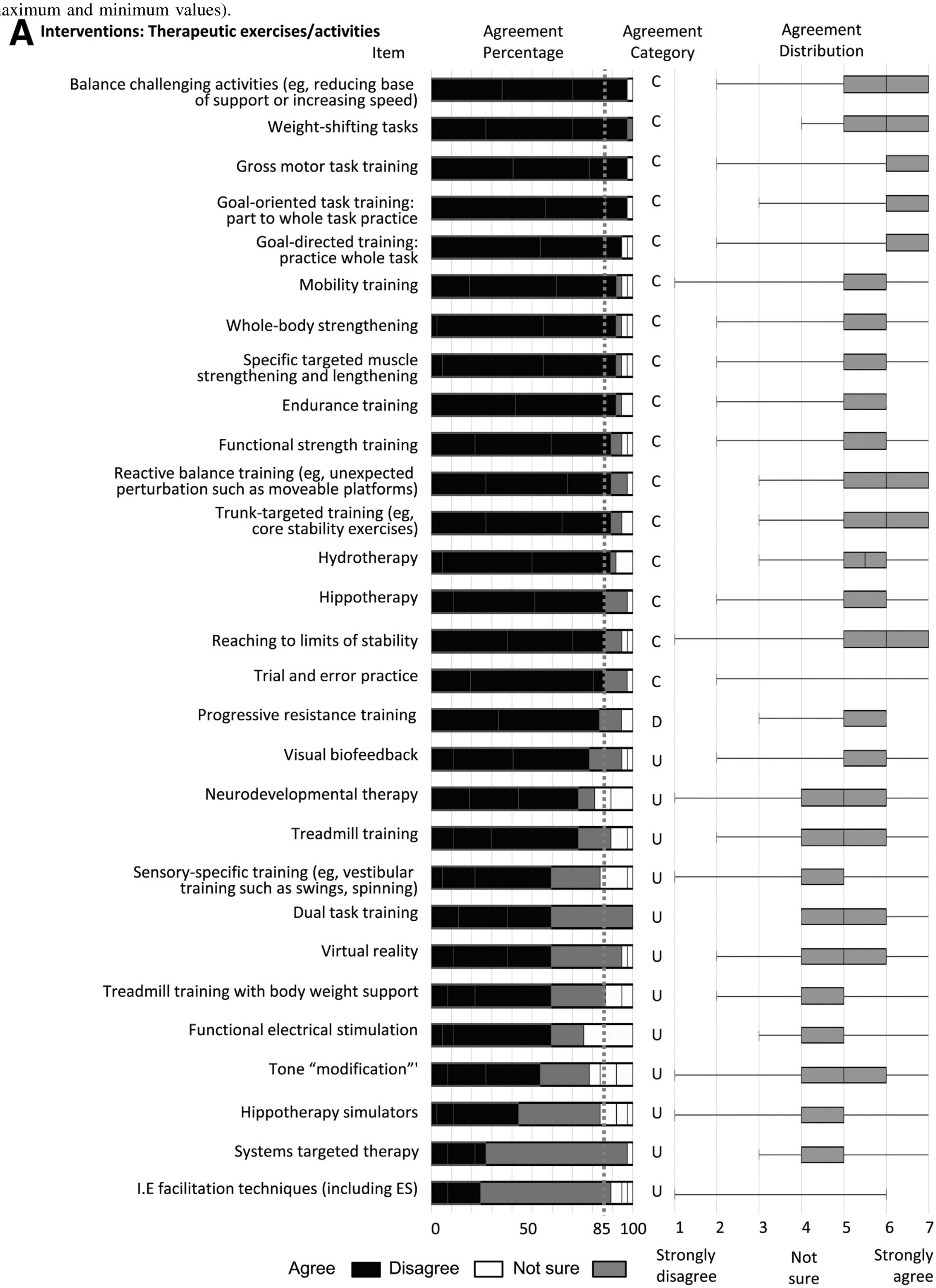


Appendix 2 *Continued*

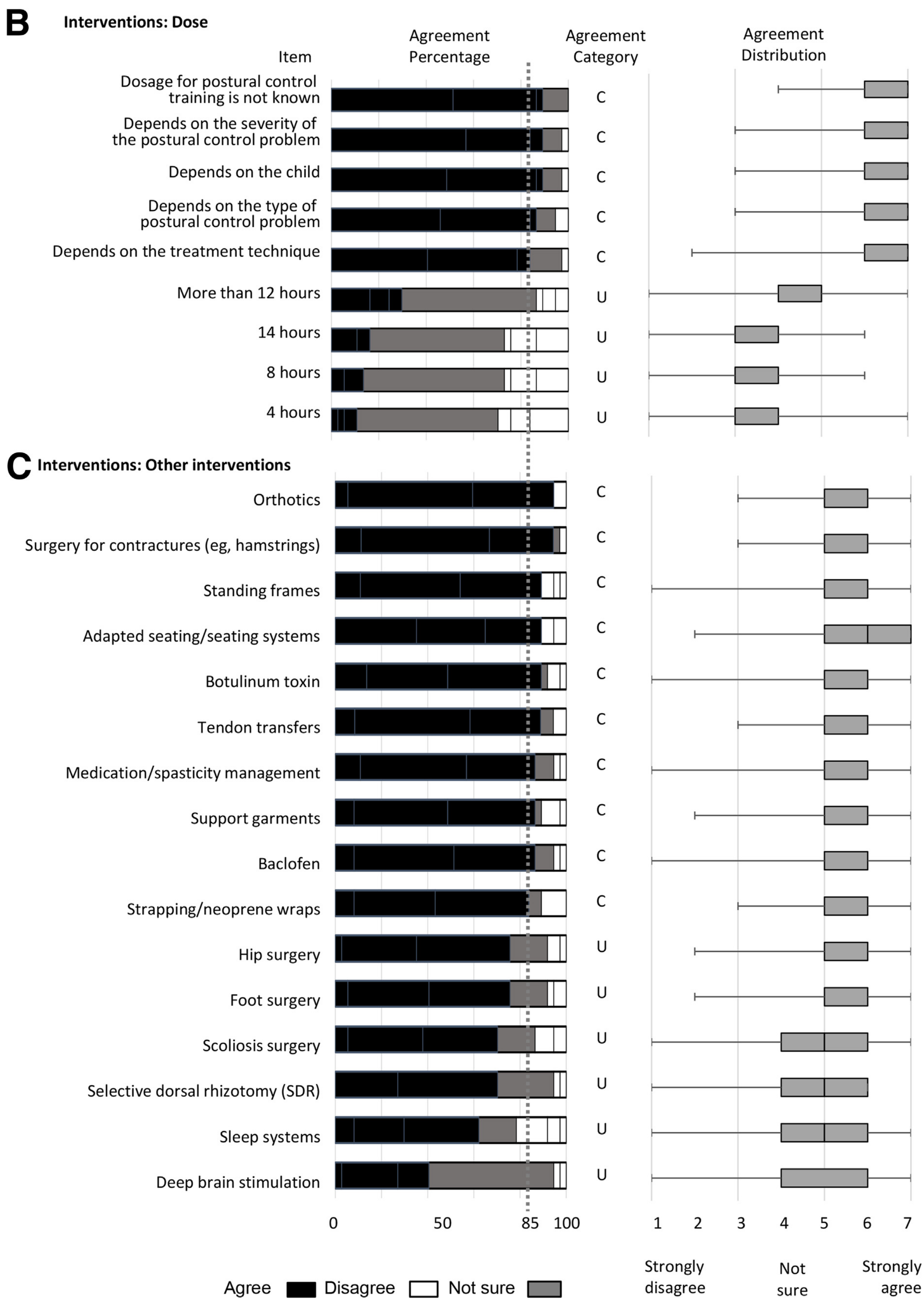


Appendix 3 Postural Control Interventions

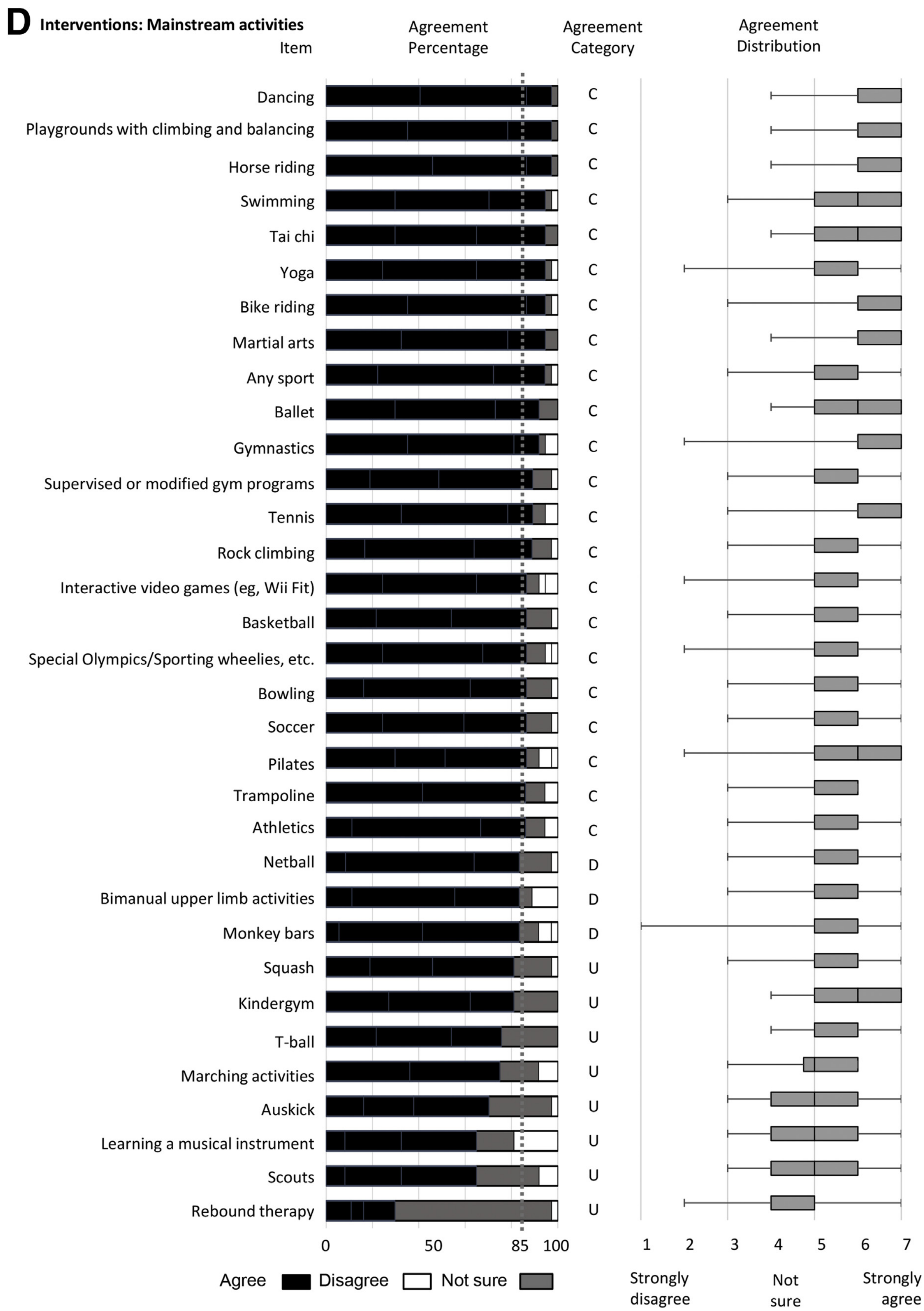
Postural control interventions for (A) therapeutic exercises/activities, (B) dose, (C) other interventions, and (D) mainstream activities, presented according to agreement percentage (85% threshold), agreement category (C, consensus; D, discordant; U, unknown), and agreement distribution (box and whisker plots with boxes representing the median and interquartile range, and whiskers representing the maximum and minimum values).



Appendix 3 *Continued*



Appendix 3 *Continued*



References

1. Rosenbaum P, Paneth N, Leviton A, et al. A report: the definition and classification of cerebral palsy April 2006. Dev Med Child Neurol Suppl 2007;109:8-14.
2. Palisano RJ, Rosenbaum P, Bartlett D, Livingston MH. Content validity of the expanded and revised Gross Motor Function Classification System. Dev Med Child Neurol 2008;50:744-50.
3. Eliasson A-C, Krumlinde-Sundholm L, Rösblad B, et al. The Manual Ability Classification System (MACS) for children with cerebral palsy: scale development and evidence of validity and reliability. Dev Med Child Neurol 2006;48:549-54.
4. Hidecker MJ, Paneth N, Rosenbaum PL, et al. Developing and validating the Communication Function Classification System for individuals with cerebral palsy. Dev Med Child Neurol 2011;53:704-10.
5. Ketelaar M, Vermeer A, Helders PJ. Functional motor abilities of children with cerebral palsy: a systematic literature review of assessment measures. Clin Rehabil 1998;12:369-80.
6. Vos-Vromans DC, Ketelaar M, Gorter JW. Responsiveness of evaluative measures for children with cerebral palsy: the Gross Motor Function Measure and the Pediatric Evaluation of Disability Inventory. Disabil Rehabil 2005;27:1245-52.
7. Novak I, Mcintyre S, Morgan C, et al. A systematic review of interventions for children with cerebral palsy: state of the evidence. Dev Med Child Neurol 2013;55:885-910.
8. Saether R, Helbostad JL, Riphagen II, Vik T. Clinical tools to assess balance in children and adults with cerebral palsy: a systematic review. Dev Med Child Neurol 2013;55:988-99.
9. Pavao SL, dos Santos AN, Woollacott MH, Rocha NA. Assessment of postural control in children with cerebral palsy: A review. Res Dev Disabil 2013;34:1367-75.
10. Dewar R, Love S, Johnston LM. Exercise interventions improve postural control in children with cerebral palsy: a systematic review. Dev Med Child Neurol 2015;57:504-20.
11. Mendoza SM, Gómez-Conesa A, Montesinos MD. Association between gross motor function and postural control in sitting in children with cerebral palsy: a correlational study in Spain. BMC Pediatr 2015;15:124.
12. Liao H-F, Hwang A-W. Relations of balance function and gross motor ability for children with cerebral palsy. Percept Mot Skills 2003;96(3 Pt 2):1173-84.
13. Gan SM, Tung LC, Tang YH, Wang CH. Psychometric properties of functional balance assessment in children with cerebral palsy. Neurorehabil Neural Repair 2008;22:745-53.
14. Harris GF, Riedel SA, Matesi D, Smith P. Standing postural stability assessment and signal stationarity in children with cerebral palsy. IEEE Trans Rehabil Eng 1993;1:35-42.
15. Westcott SL, Lowes LP, Richardson PK. Evaluation of postural stability in children: current theories and assessment tools. Phys Ther 1997;77:629-45.
16. Kazon S, Grecco LA, Pasini H, et al. Static balance and function in children with cerebral palsy submitted to neuromuscular block and neuromuscular electrical stimulation: study protocol for prospective, randomized, controlled trial. BMC Pediatr 2012;12:53.
17. Kurz MJ, Arpin DJ, Corr B. Differences in the dynamic gait stability of children with cerebral palsy and typically developing children. Gait Posture 2012;36:600-4.
18. Shumway-Cook A, Woollacott MH. Normal postural control. Motor control: translating research into clinical practice. 4th ed. Baltimore: Lippincott Williams & Wilkins; 2012.
19. Horak FB. Clinical measurement of postural control in adults. Phys Ther 1987;67:1881-5.
20. Horak FB, Wrisley DM, Frank J. The Balance Evaluation Systems Test (BESTest) to differentiate balance deficits. Phys Ther 2009;89:484-98.
21. Hasson F, Keeney S. Enhancing rigour in the Delphi technique research. Technol Forecast Soc Change 2011;78:1695-704.
22. McIntyre S, Novak I, Cusick A. Consensus research priorities for cerebral palsy: a Delphi survey of consumers, researchers, and clinicians. Dev Med Child Neurol 2010;52:270-5.
23. Cheong SK, Lang CP, Hemphill SA, Johnston LM. What constitutes self-concept for children with CP? A Delphi consensus survey. J Dev Phys Disabil 2016;28:333-46.
24. Hasson F, Keeney S, McKenna H. Research guidelines for the Delphi survey technique. J Adv Nurs 2000;32:1008-15.
25. De Villiers MR, De Villiers PJ, Kent AP. The Delphi technique in health sciences education research. Med Teach 2005;27:639-43.
26. Massion J. Postural control system. Curr Opin Neurobiol 1994;4:877-87.
27. Russell DJ, Avery LM, Walter SD, et al. Development and validation of item sets to improve efficiency of administration of the 66 item Gross Motor Function Measure in children with cerebral palsy. Dev Med Child Neurol 2010;52:e48-54.