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Gross Motor Assessment Tools for Children 0-12 Years of Age Using Telehealth: A Scoping Review

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ABSTRACT
Objective: The objective of this review was to understand the scope of evidence relating to the use of telehealth for gross motor assessment tools in children 0-12 years of age. **Background:** Telehealth has been widely used by physiotherapists since the start of the Covid-19 pandemic, however, little is known about the validity and reliability of using gross motor assessment tools via telehealth. Gross motor assessment tools are used by physiotherapists to understand motor function, support diagnoses of motor disorders, and plan and evaluate interventions. Qualitative research identifies a lack of confidence by physiotherapists in undertaking physical assessment via telehealth. **Method:** A comprehensive search was undertaken of MEDLINE, Scopus, CINAHL, Physiotherapy Evidence Database (PEDro) and OTseeker in August 2022. Grey searching was also implemented. Two independent reviewers identified articles for inclusion and critically appraised the articles. Data was analysed using a narrative review. **Results:** 34 studies met the inclusion criteria.

Keywords: child, telehealth, gross motor, assessment

INTRODUCTION

Telehealth can be defined as the synchronous (real time) or asynchronous (retrospective) provision of assessment, diagnosis, intervention and health information remotely using telecommunications technology.[1,2] Other terms commonly used are telemedicine, telerehabilitation and telepractice.[1] During the Covid-19 pandemic, telehealth experienced a steep uptake which has not returned to pre-pandemic levels.[3] Physiotherapists reported that while they considered telehealth acceptable where face-to-face services were not available, they were not confident in using it for standardised physical assessments including gross motor assessments.[4] To understand the potential of telehealth to provide remote services in the future, it is important to understand how the scope of the evidence relating to the use of gross motor assessment tools that have been used via telehealth.

Gross motor assessment tools are used to describe or quantify a person's level of gross motor function.[5] Gross motor function is the ability to perform whole body motor tasks such as lying, rolling, sitting, crawling, walking and running.[6] Gross motor assessment tools typically have several items or skills that are can be recorded as present, absent or incomplete.[5] Whilst physiotherapists specialise in movement and motor function and are often involved in conducting gross motor assessments; other clinicians such as occupational therapists, nurses and doctors may also be involved.[7] Gross motor assessment tools can be used for a variety of purposes including to diagnose a condition, predict prognosis, compare performance to peers or to evaluate an intervention.[5]

There are various types of assessments a clinician can use to understand a child's gross motor function. The Paediatric Evaluation of Disability Inventory (PEDI) is a carer report of a child's function.[8] Other tools are performance based where the clinician must see the child do each skill, for example the Hammersmith Infant Neurological Examination (HINE),[9] Peabody Developmental Motor Scales-2 (PDMS-2),[5] and the Bayley's Scales of Infant and Toddler Development-III.[5] Assessment characteristics can include criterion versus norm referenced assessment; where a criterion referenced test provides a specific benchmark to score against while norm referenced compares the child's performance to how a group of children would perform when assessed at the same age.[10] Standardisation refers to an assessment being performed in a consistent way.[10] For example, the PDMS-2 is standardised, performance based, norm referenced, assessment tool; meaning it is delivered the same way each time by a clinician watching each skill and the child's performance is compared to how well other children would do in the same assessment.[11] The Neurological Sensory Motor Developmental Assessment (NSMDA) is an example of a standardised, performance based, criterion referenced assessment; differing from the PDMS-2 because it does not compare a child's performance to age matched peers.[12] It is common for gross motor assessment tools to assess more than just gross motor function, for example the PDMS-2,[11] and the Bayley-III have a gross motor domain in addition to fine motor and other domains of development.[13]

Telehealth has challenged clinicians' abilities to conduct performance based assessments while parent reported assessments have been relatively easy to conduct via telehealth.[4] Parent reported assessments, such as the Developmental Assessment of Young Children (DAY-C) and the PEDI require the parent to respond to interviewing from the clinician.[8,14] Performance based assessments may require the child to be placed in a position or may even require physical manipulation.[15] When using telehealth, physiotherapists reported choosing parent reported assessment tools to estimate gross motor skills as they were not confident in the accuracy of performance based assessments.[4] Physiotherapists also reported they could not communicate with parents on how to facilitate movements and positions required for assessment.[4] Whilst the above mentioned DAY-C and PEDI are valid and reliable, they are used in conjunction with performance based assessments to build a clinical picture or to diagnose a condition.[5,8,14]

It is important that children have access to a variety of assessments suitable to assess developmental delays and determine underlying diagnoses.[16,17] First, early identification of developmental delay and any underlying conditions triggers early intervention, with the aim of maximising a child's neuroplastic window.[9] Second, the National Disability Insurance Scheme (NDIS), which funds services to people in Australia who have a disability, does not accept parent reported assessments on their own as proof of diagnosis.[18] For example, a diagnosis of Developmental Coordination Disorder requires a parent report and a performance based assessment such as the MABC-2.[19] For areas where there is a long wait for face-to-face assessments, telehealth offered by adequately staffed metropolitan services becomes a potential modality for delivering these assessments in a timely manner.[20]

The aim of the scoping review is to understand the scope of evidence relating to the use of telehealth for gross motor assessment tools in children 0-12 years of age. The secondary aim is to understand which tools may benefit from validity and reliability testing.

The questions for this review are:

1. What gross motor assessment tools for children 0-12 years of age have been used via telehealth?
2. Which gross motor assessment tools have been assessed as valid and reliable for use via telehealth for children 0-12 years of age?

METHODS

Protocol and Registration

This review is registered with the Open Science Framework: DOI 10.17605/OSF.IO/TKWRN

Eligibility Criteria:

The inclusion and exclusion criteria for this review are specified in Table 1.

Table 1. Eligibility Criteria

Study Characteristics	Inclusion Criteria
Study Types	All study designs
Participants	Children 0-12 years of age
Concept	Studies from the paediatric field of health care that examine standardised and performance based gross motor assessment tools, with or without assessing other areas of development aside from gross motor (e.g. fine motor, cognition)
Context	Synchronous and asynchronous telehealth. Studies must be in English.

Information Sources

Data bases chosen were MEDLINE, Scopus and CINAHL; these are comprehensive medical and allied health databases. PEDro and OTseeker were also searched to comprehensively find articles relevant to groups who conduct gross motor assessments including physiotherapists and occupational therapists.

Search Strategy

A comprehensive search of the literature was conducted by two independent reviewers on the 16th of August, 2022. Reference lists of included articles were hand searched for additional eligible articles. A generic example of the search strategy is in Table 2.

Table 2. Search Strategy

Search terms
child OR children OR toddler* OR baby OR babies OR infant* AND telehealth OR tele-health OR telerehab* OR tele-rehab* OR telemed* OR tele-med* OR telepract* OR tele-pract* OR videobased OR video based OR video observation) AND motor OR movement OR developmen* NEAR (assessment OR function)

Study Selection

After the search was completed, the results were exported to Endnote (Clarivate, Philadelphia, PA, USA) and duplicates removed. Titles and abstracts were screened and any ineligible articles excluded. The full texts of remaining articles were screened against the eligibility criteria by two independent reviewers (CG and AJ). Discrepancies were resolved through discussion with a third reviewer (MC) available in the case that a consensus was not reached. Study screening and selection was recorded in a PRISMA flow diagram (Figure 1). The PRISMA checklist for scoping reviews is attached as Appendix 1.

Data Collection

Data was extracted from eligible articles using a form adapted from the JBI data extraction template. The two reviewers (AJ and CG) independently extracted data and any disagreements were resolved through discussion. Data from the forms was exported to Microsoft Excel for ease of analysis. Any inconsistencies were resolved by going back through articles and updating the data. Charted data included study design, analysis, aims, participants, gross motor assessment tools used, outcome measures, reliability, validity and perspectives of users of the assessment.

Determination of Study Quality

A quality assessment was conducted using the Crowe Critical Appraisal Tool (CCAT).[21] This tool can be used for any study design which suited the heterogeneity of the included articles. The CCAT is used to assess quality across eight domains: preliminaries, introduction, design, sampling, data collection, ethical matters, results and discussion.[22] The CCAT prompts the scorer to consider bias in design and discussion domains. Each domain is assigned a maximum score of five which represents the best possible quality for that category. The total possible score is 40 which can be converted to a percentage.[22] Two independent reviewers (AJ and CG) applied the CCAT to included articles. Where there were discrepancies, the two reviewers discussed to reach consensus. In the event consensus could not be reached, a third reviewer (HL) was available to apply the CCAT.

Synthesis of Results

As this is a scoping review and includes a wide variety of study designs, a meta-analysis was not possible. Rather, a narrative synthesis was used, which is a textual analysis and is flexible to different study designs and the wide variety of outcomes measured.[23]

RESULTS

Thirty-four articles were eligible for inclusion in the review. There was agreement in eligible studies by the two reviewers. The characteristics of each source of evidence and CCAT score is shown in Table 3. Figure 1. Shows the PRISM flowchart.

Figure 1. PRISMA Flowchart for a Scoping Review

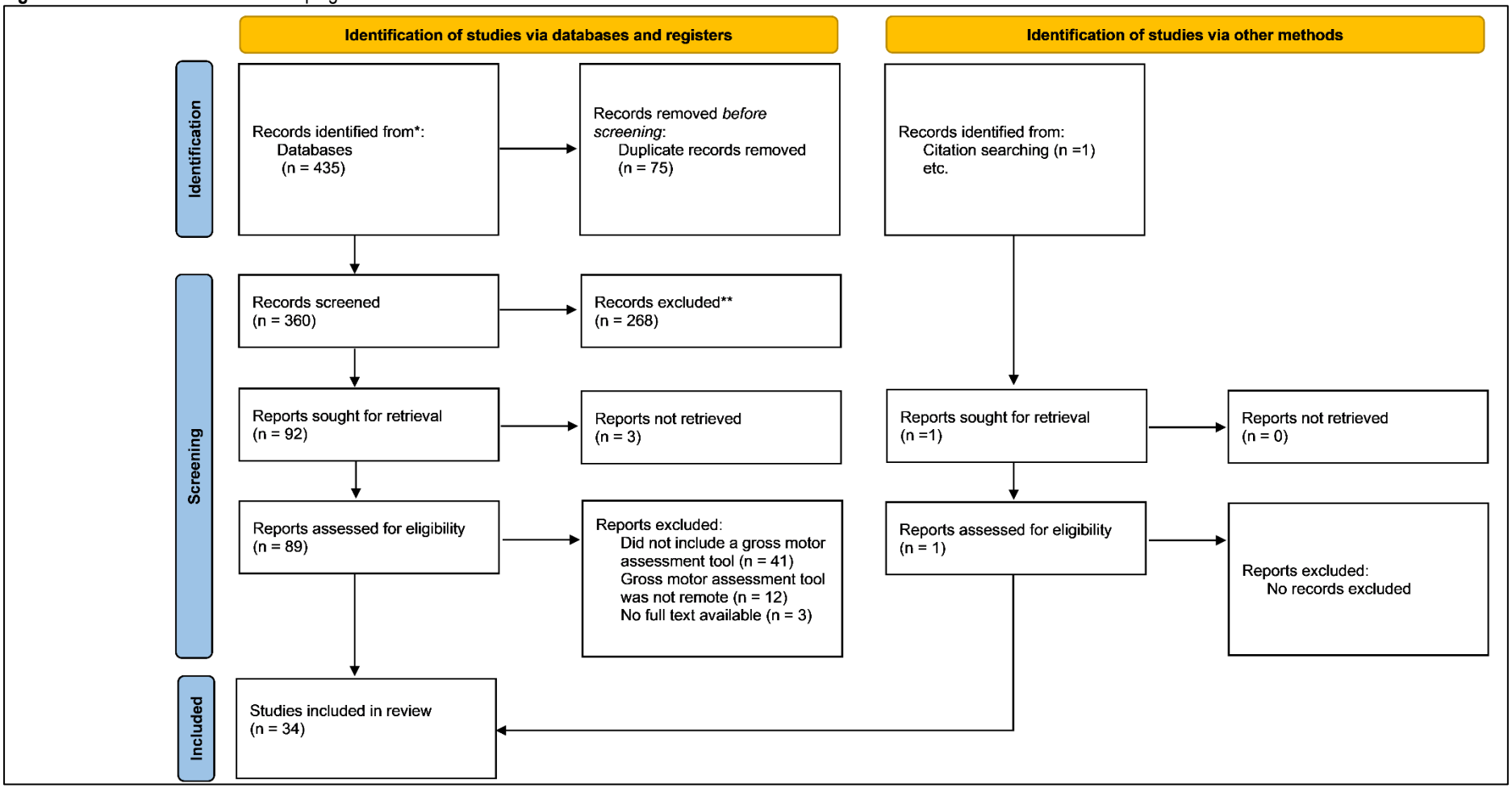

Table 3. Study Characteristics Table

Study	Population	Design	Assessment tool	Telehealth assessment details	Outcomes measured	Results	CCAT score
Adde et al 2009	82 pre and term infants at low and high risk of developing CP 10-18 weeks post term	Feasibility study	General movements assessment (GMA)– CBVA	Video recordings taken in clinic and scored retrospectively	Sensitivity and specificity of spatial centre of active pixels to identify Fidgety Movements	Centroid standard deviation (C_{SD}) threshold 2.14, with Sensitivity 81.5%, Specificity 70%, AUC .83, 95%CI (.75, .90)	65%
Adde et al 2010	30 high risk infants 23-42 weeks gestational age	Prospective observational study	GMA – CBVA	Video recordings taken in clinic and scored retrospectively	Sensitivity and specificity of the C_{SD} to identify children with Cerebral Palsy	C_{SD} threshold, 2.45 (with Sensitivity 85%, Specificity 71%, AUC .84, 95%CI (.69, .98)	73%
Adde et al 2013	52 pre term and term infants 9-17 weeks post term	Comparison study of one vs two videos	GMA– CBVA	Video recordings taken in clinic and scored retrospectively	Sensitivity and Specificity of the C_{SD} (two videos) to identify children with Cerebral Palsy	Sensitivity 100% Specificity 74% mean of 2 videos 10% improvement on single video	75%
Adde et al 2018	27 low to moderate risk pre term infants 3-5 weeks post term and 10-15 weeks post term	Longitudinal study	GMA – CBVA	Video recordings taken in clinic and scored retrospectively	Variability of the C_{SD} in the writhing period (3-5 weeks) vs fidgety period (10-15 weeks)	The mean variability of the C_{SD} was 7.5% lower during the period of fidgety GMs than during the period of writhing GMs p = 0.004	73%
Adde et al 2021	69 high risk infants 8-23 weeks post term	Multi centre prospective observational study	GMA – In-motion-app	Parent taken videos using In-motion-app, scored retrospectively	Parent perceptions Accuracy of predicted body points	58.7% parents agreed the app was easy to use 80.9% accuracy of predicted body points	88%
Boonzaaijer et al 2017	48 infants from 1.5-19 months	Validity study – telehealth vs face-to-face administration	Alberta Infant Motor Scale (AIMS)	Parent taken video while clinician on video call to observe motor skills – scored retrospectively 12 testers completed assessments	Inter-rater, intra-rater reliability and concurrent validity using ICC Parent experience	Inter-rater ICC .99 (3 raters) Intra-rater ICC .97 Concurrent validity ICC .99 Mean difference in scores.46 CI 95% (−0.116, 1.033) 94% of parents reported video observation easy to perform	78%
Einspieler et al 2016	233 infants from 27-45 weeks post menstrual age	Comparison of global general movements and detailed general	GMA	Video recordings taken in clinic and scored retrospectively	Global Score Motor Optimality Score (GMOS)	GMOS differs significantly between cramped synchronised, normal and poor repertoire, p<0.01	73%

Study	Population	Design	Assessment tool	Telehealth assessment details	Outcomes measured	Results	CCAT score
		movements scores				Cramped synchronised and chaotic do not differ significantly from each other, p=0.09	
Emery et al 2022	10 boys with Duchenne Muscular Dystrophy from 4-17 years	Feasibility study	North Star Ambulatory Assessment	Synchronous assessment appointment with parents and child at home and 2 physiotherapists independently rating remotely	Clinician perceptions Inter-rater reliability using ICC	Clinicians reported stand on heels difficult to see Inter-rater ICC .98 (2 raters) CI 95% (.93, 1.00)	80%
Fjørtoft 2008	25 infants 3-5 months post term	Reliability study	Assessment of Motor Repertoire 3-5 months	Video recordings taken in clinic and scored retrospectively	Overall measurement error reporting standard deviation Inter-rater reliability using ICC	SD 3.47 ICC .87 (4 raters)	83%
Fyfe 2007	97 girls with Rett syndrome from 8-18 years	Reliability study	Video based assessment of girls with Rett Syndrome (Motor domain based off Gross Motor Function Measure-88)	Parents recorded videos at home using a filming protocol and video examples – asynchronous, scored retrospectively	Inter-observer reliability using Cohen's kappa coefficient Content validity	44 of 61 motor items k>.8 (considered excellent) (2 raters) Stated content validity supported by literature	68%
Gavazzi et al 2021	21 people with leukodystrophy aged 1-52 years	Reliability and agreement study	Gross Motor Function Measure-88 (GMFM)	Synchronous assessment appointment with parents and child at home and 2 physiotherapists – videos were recorded to score later for inter-rater reliability	Inter-rater and intra-rater reliability using ICC Agreement using Lin's concordant correlation coefficient	Inter-rater ICC .996 (2 raters) CI 95% (.964, .999) Intra-rater ICC .999 CI 95% (.996, 1.0) Agreement CCC .997 CI 95% (.993, .998)	80%
Groos et al 2022	1424 recordings of infants 9-18 weeks post term	Comparison study of eight different	GMA – CBVA	Video recordings from a database	Consistency	Consistency ICC .64 Agreement ICC .96	73%

Study	Population	Design	Assessment tool	Telehealth assessment details	Outcomes measured	Results	CCAT score
		pose estimation models		scored retrospectively	and agreement compared to human experts using ICC	CI 95% (.91, .99)//for best pose estimation model	
Groos et al 2002	557 infants at high risk of perinatal brain injury 9-18 weeks corrected term age	Prognostic study of deep based computer learning to predict Cerebral Palsy	GMA – CBVA	Video recordings taken in clinic and scored retrospectively	Sensitivity Specificity PPV NPV	Sensitivity 71% CI 95% (48, 89) Specificity 94% CI 95% (88, 98) PPV 68% CI 95% (45, 86) NPV 95% CI 95% (89, 98)	88%
Heineman et al 2008	80 high and low risk infants 4-18 months corrected age	Reliability and validity study of the Infant Motor Profile compared to the Alberta Infant Motor Scale	Infant Motor Profile (IMP)	Video recordings taken in clinic and scored retrospectively	Inter-rater reliability, intra-rater reliability and concurrent validity using Spearman's Rho correlation coefficient	Inter-rater r = .90 (2 raters) CI 95% (.80, .90) Intra-rater r = .90 CI 95% (.80, 1.0) Concurrent validity r = .80 p<.0005	75%
Kirthika et al 2017	30 pre term infants 0-18 months corrected age	Reliability study	AIMS	Assessment conducted in person and video recorded. Reliability measures used video recordings.	Inter-rater and intra-rater reliability using ICC	Inter-rater ICC .96 (3 raters) Intra-rater ICC .99	70%
Kraus de Camargo et al 1998	20 children from 1-28 months	Reliability study	Video Documentation of Motor Behaviour	Video recordings taken in clinic and scored retrospectively	Inter-rater reliability measured using Cohen's kappa Agreement with Gross Motor Function Measure using Bland Altman limits of agreement	k=.85 (7 raters) Bland Altman limits of agreement .30-.69 p <0.01-<0.05 for each domain correlation with GMFM	50%
Maitre et al 2021	97 high risk infants from 3-36 months	Longitudinal Study	Hammersmith Infant Neurological Examination (HINE), GMA	Synchronous neurosurveillance appointments with parents at home and clinicians at hospital	Parent satisfaction Sessions missed	>90% of parents agreed or strongly agreed that assessments were easy to conduct 0% of telehealth sessions missed	58%

Study	Population	Design	Assessment tool	Telehealth assessment details	Outcomes measured	Results	CCAT score
Nicola et al 2018	59 children 5-11 years	Validity and feasibility study	Movement Assessment Battery for Children – 2 (MABC-2)	Child assessed at school in person on one occasion and remotely on one occasion - synchronous	Bland Altman limit of agreement for telehealth vs face-to-face delivery	Bland Altman -3.15 to 3.22 CI 95% −0.39, 0.46 p=0.86 //non-significant difference between telehealth and face-to-face scores	80%
Peyton et al 2021	150 high risk infants 10-15 weeks corrected age	Reliability study	GMA	Video recordings from a database scored retrospectively	Inter-rater reliability of raters with varying experience using Gwet's AC_1	Reliability better for raters with more experience AC_1 = .57–.98 than the rater (2 raters) with less experience (1 rater) AC_1 = .32–.61 p=.13-.66 across 3 raters for each movement category// insignificant difference between scores	85%
Philippi et al 2014	67 low and high risk infants 2.5-3.5 months corrected age	Predictive validity study	GMA - CBVA	Video recordings taken in clinic and scored retrospectively	Sensitivity Specificity PPV NPV (When predicting Cerebral Palsy or no Cerebral Palsy)	Clinician: Sensitivity 100% CI 95% (.95, 1.0) Specificity 79% CI 95% (.68, .87) PPV 45% CI 95% (.34, .57) NPV 100% (.05-1.0) CBVA: Sensitivity 90% CI 95% (.81, .95) Specificity 95% CI 95% (.87, .98) PPV 75% CI 95% (.63, .84) NPV 98% CI 95% (.91, 1.0)	65%
Ricci 2020	N/A	Commentary paper of Yeh 2020	GMA	N/A	N/A	Discusses that clinicians should encourage parents to take videos	0%
Saini et al 2021	11 high risk infants 50-56 weeks post menstrual age	Feasibility study	GMA	Video recordings taken in clinic and scored retrospectively	N/A	Stated GMA a feasible tool for follow up of high risk infants	20%
Schlichting et al 2022	15 infants at high risk of development delay 3-18 months	Longitudinal study	GMFM, AIMS, HINE, GMA,	GMA recorded by parents and scored retrospectively HINE, GMFM and AIMS talked through to parent while parent at home, video	Feasibility measured by participants who completed assessment and number of adverse events Perception of scorers	10 assessments completed 0 adverse events 100% of scorers reported easy to score videos	88%

Study	Population	Design	Assessment tool	Telehealth assessment details	Outcomes measured	Results	CCAT score
				recorded to score retrospectively			
Sorsdahl et al 2008	26 children with Cerebral Palsy 2-13 years	Reliability study	Gross Motor Performance Measure (GMPM)	In person assessment at school or clinic, video taped to be scored retrospectively	Inter and intra observer reliability using ICC	Inter observer ICC .91 (2 raters) CI 95% (.81, .96) Intra observer ICC .97 CI 95% (.93, .99)	75%
Spittle et al 2016	Pre term and/or extremely low birth weight infants	Prospective cohort study protocol	GMA – Baby Moves App	Parent taken videos using Baby Moves App, scored retrospectively	Neurodevelopmental outcome Parent satisfaction	N/A	73%
Støen et al 2017	150 high risk infants 10-15 weeks post term age	Prospective cohort study	GMA - CBVA	Video recordings taken in clinic and scored retrospectively	Variation of the spatial centre of motion (C_{SD}) in normal, absent and sporadic fidgety movements	Normal fidgety movements =.32 CI 95% (.31, .33) Absent or sporadic fidgety movements = .38 CI 95% (.36, .40) p<0.001	83%
Tekerlek et al 2021	18 infants with cystic fibrosis and 20 infants with no diagnosis 10-19 weeks post term age	Prospective cohort study	GMA	Video recordings taken in clinic and scored retrospectively	Motor optimality score	Motor optimality score was significantly lower in infants with CF (median = 18.5, range = 7–28) compared to the healthy infants (median = 26, range = 16–28) p < .01	83%
Tveten et al 2020	50 infants 3-12 months	Reliability study	Infant Motor Profile	Video recordings taken in clinic or home settings and scored retrospectively	Inter-rater and intra-rater reliability using ICC	Inter-rater ICC = .86-.91 (3 raters) CI 95% (.76, .95) Intra-rater ICC = .95 CI 95% (.91, .97)	88%
Valle et al 2015	75 term born, healthy infants recorded during fidgety period (2	Reliability study	GMA – CBVA	Video recordings taken in clinic and scored retrospectively	Intra-rater reliability using ICC of the centroid of motion	ICC = .80 CI 95% (.69, .88)	75%
Wang et al 2022	15 infants with Prader Willi Syndrome 3-5 months	Reliability and agreement study	Assessment of Motor Repertoire 3-5 months	Video recordings taken in clinic and scored retrospectively	Inter-rater and intra-rater reliability using ICC Agreement using Cohen's kappa	Inter-rater ICC = .93 (3 raters) CI 95% (.84, .98) Intra-rater ICC = .95 – .98 CI 95% (.85, .99) Agreement k = .63-1.0	88%

Study	Population	Design	Assessment tool	Telehealth assessment details	Outcomes measured	Results	CCAT score
Wu et al 2021	12 infants	Predictive validity study	GMA – CBVA	Video recordings taken in clinic and scored retrospectively	Sensitivity Specificity Accuracy	Sensitivity 100% Specificity 87.5% Accuracy 91.7%	75%
Yeh et al 2016	37 infants 35-60 weeks post menstrual age	Reliability study	GMA	Video recordings taken in clinic and scored retrospectively	Intra-rater reliability of global score and of motor optimality score using ICC	Global score ICC .95 Motor optimality score ICC .90	78%
Yeh et al 2020	29 infants 49 to 60 weeks post menstrual age	Validity study of parent taken videos compared to clinician taken videos	GMA	Video recordings taken in clinic and scored retrospectively and parent recorded videos at home using an instructional leaflet – scored retrospectively	Agreement between parent/clinician videos and content validity of instructional leaflet using Cohen's kappa	Agreement k = .87 Content validity k = .27-.53	80%
Zischke et al 2021	39 studies	Systematic review	MABC-2 (Nicola et al 2018)	N/A	Reported as per Nicola et al 2018	N/A	93%

* Alberta Infant Motor Scale (AIMS), Computer Based Video Analysis (CBVA), Intra Class Correlation Coefficient (ICC), Cohen's kappa (k), Positive Predictive Value (PPV), Negative Predictive Value (NPV), Spearman's Rho Correlation Coefficient (r), Lin's Concordant Correlation Coefficient (CCC), Standard Deviation (SD), Confidence Interval (CI)

Study Designs

Study designs included 16 reliability and validity studies,[24-40] five feasibility studies,[41-44] five prospective cohort studies,[45-49] three longitudinal studies,[15,50,51] three comparison studies, [52-54] one commentary piece,[55] and one systematic review.[56]

Included Assessments

The General Movements Assessment (GMA and its sister tool, the Assessment of Motor Repertoire 3-5 months were the most frequently investigated tool (n=22). The GMA is a performance-based assessment of motor repertoire. It is asynchronous (only ever assessed retrospectively using video recordings) and is used in infants from pre-term to 20 weeks to assess the presence and frequency of spontaneous movements. Abnormal or absent movements are predictive of Cerebral Palsy. Clinicians require a high level of training and repeat assessments to stay reliable as assessors.[57] The Assessment of Motor Repertoire 3-5 months is a particular method of scoring general movements that gives a Motor Optimality Score, in addition to the global score of the GMA.[58] So, for example, the global score might say a child has normal movements, while the Motor Optimality Score will offer a description of frequency and type of spontaneous and intentional movements, offering more information as to what scores might mean for a particular child.[58]

In ten of the 22 studies, the GMA was scored using computer video-based analysis rather than a clinician completing the scoring. As shown in Table 3, these studies found sensitivity between 71 to 100% and specificity between 70% and to 100%.[33,41,44,45,50] Positive predictive value was between 68% and 75% and negative predictive value was between 95% and 98%.[33,44] Agreement between Computer Based Video Analysis (CBVA) and clinicians was reported with an ICC of .96.[54] In two of the 22 studies a smart phone app was used to take the video.[46,47] Parents reported the In Motion app was easy to use (58%) while the Baby Moves app has not yet had outcomes reported.[46,47] The ten studies that used clinician scoring for the GMA showed that experienced raters had better inter-rater reliability than inexperienced raters, that the GMA is feasible for parents to do at home and that parent taken videos have agreement with clinician videos (k=.87).[15,32,39] One study reported that infants with cystic fibrosis had lower Motor Optimality Scores than healthy infants.[49] Clinical significance reported by p value or confidence interval (CI) varied and is shown in Table 3.

The Gross Motor Function Measure-88 (GMFM-88) was investigated in three studies.[15 27 28] One of the studies adapted the tool to use as the motor portion of a larger assessment.[27] The GMFM-88 is a measure of gross motor function validated for use with children with Down Syndrome and Cerebral Palsy.[59] It contains 88 items across five domains: lying/rolling, sitting, crawling/kneeling, standing and walking/running/jumping. It is valid for children 5 months-16 years of age.[59] Gavazzi et al (2021) reported inter-rater and intra-rater reliability of the GMFM-88 through telehealth using Lin's Concordant Coefficient with .995 and .999 respectively.[28] Confidence intervals of 95% were (.964, .999) and (.996, 1.0) respectively.[28] Fyfe et al reported inter-rater reliability of the adapted GMFM-88 with Cohen's Kappa greater than .80 for 44 out of 61 items used; a measure of clinical significance was not reported.[27] Schlichting et al reported the GMFM-88 was feasible through telehealth with no adverse outcomes and 100% of scorers reporting it was easy to score the videos.[15]

The Hammersmith Infant Neurological Examination (HINE) was investigated in two studies.[15 51] The HINE has 26 items assessing cranial nerve function, posture, movements, tone, reflexes and reactions. HINE scores of less than 65 at 12 months are highly predictive of Cerebral Palsy. HINE scores of less than 40 at any age are highly predictive of non-ambulant types of Cerebral Palsy. Similar to the GMA, it can be used in conjunction to an MRI to diagnose Cerebral Palsy. It can be used for children 2-24 months of age. Maitre et al (2021) reported greater than 90% of parents found the telehealth assessments easy to conduct.[51] Schlichting et al (2022) reported that the reflexes portion of the HINE could not be completed on telehealth but that there were no adverse events and 100% of scorers found the videos easy to score.[15]

The Infant Motor Profile (IMP) was investigated in two studies.[29 35] Similar to the GMA, the original form of this tool is intended to be scored from video recordings. It is valid for use in infants from 3-18 months.[29] It has 80 items evaluating motor ability, movement variability, ability to select motor strategies, movement symmetry and fluency.[35] Heineman et al (2008) reported inter-rater and intra-rater reliability of r = .90 using Spearman's rho correlation coefficient (95% CI of (.80, .90) and (.80, 1.0) respectively) and concurrent validity with the AIMS as r = .80 (p<.0005).[29] Tveten et al (2020) compared home videos with clinic videos and found inter-rater and intra-rater reliability using ICC as .86-.91 and .95 respectively.[35] Confidence intervals of 95% were reported as (.76, .95) and (.91, .97) respectively.[35]

The North Star Ambulatory Assessment was investigated in one study.[42] This is a measure of motor function in ambulant children with Duchenne Muscular Dystrophy. It is designed to monitor changes over time as this population experiences progression of muscular weakness and loss of skills. It has 17 items including sit to stand, steps, standing from the floor, hop and run. Inter-rater reliability was reported using ICC of .98 (95% CI .93, 1.00).[42] Clinicians reported stand on heels item was difficult to score on carpet.[42]

The Alberta Infant Motor Scale (AIMS) was investigated in three studies.[15 24 30] This tool investigates gross motor skills in children from 0-18 months. It assesses infant movements in supine, prone, sitting and standing.[24] Boonzaaijer et al (2017)

compared telehealth assessments to face-to-face using ICC to report inter-rater and intra-rater reliability and concurrent validity with values of .99, .97 and .98 respectively.[60] Ninety four percent of parents reported the video observation was easy to perform.[24] Kirthika et al (2017) studied the AIMS on pre term infants and used video recordings to establish inter-rater and intra-rater reliability with ICC values of .96 and .99 respectively.[30] Schlichting et al reported no adverse outcomes and 100% of scorers reported it was easy to score the video assessments. Clinical significance of ICC values was not reported.[30,60]

The Video Documentation of Motor Behaviour (VDMB) was investigated in one study.[25] This was a novel tool designed by the study authors to assess motor behaviour from video recordings. This was used in children from 0-3 years old and included 11 items. Inter-rater reliability was reported with a Kohen's Cappa value of .85 agreement with the GMFM-88 was reported with Bland Altman limits of agreement of .30-.69.[25] Clinical significance ranged from p <0.01-<0.05 for each of the VDMB domains' correlation with the GMFM.[25]

The Movement Assessment Battery for Children-2 (MABC-2) was investigated in one study.[31] The MABC-2 is a tool designed to identify motor impairments in children from 3-16 years of age. It has three different age categories: 3-6, 7-10 and 11-16 with different criteria for each category. There are ten items tested across the domains of manual dexterity, aiming and catching and balance.[31] Nicola et al reported Bland Altman Limits of Agreement from -3.15 to 3.22 when comparing telehealth to face-to-face.[31] The difference between face-to-face and telehealth scores was non-significant (CI 95% (−0.39 to 0.46) and p=0.86).[31]

The Gross Motor Performance Measure (GMPM) was investigated by one study.[34] The tool has 20 criterion-based items that assess the attributes of alignment, stability, coordination, weight shift, and dissociation. It is valid to use with children 0-12 years of age who have Cerebral Palsy.[62] Sorsdahl et al reported inter-rater reliability and intra-rater reliability using ICCs .91 and .97 respectively.[34] Confidence intervals of 95% were (.81-.96) and (.93-.99) respectively.[34]
Table 4 summarises the reliability and validity reporting for each assessment tool.

Table 4. Reliability and Validity Summary for Each Tool

Tool	Population	Inter-rater reliability reported	Intra-rater reliability reported	Concurrent validity reported
AIMS	Infants (general) High risk infants	Yes Yes	Yes Yes	Yes No
Assessment of Motor Repertoire 3-5 months	Infants (general) High risk infants Infants with Prader Willi Syndrome	Yes No Yes	No No Yes	No No Yes
GMA	Infants (general) High risk infants Infants with Cystic Fibrosis	Yes No No	Yes No No	Yes No No
GMFM-88	Leukodystrophy Girls with Rett Syndrome High risk infants	Yes Yes No	Yes No No	Yes No No
GMPM	Children with Cerebral Palsy	Yes	Yes	No
HINE	High risk infants	No	No	No
IMP	Infants (general) High risk infants	Yes Yes	Yes Yes	No Yes
MABC-2	School children	No	No	Yes
North Star Ambulatory Assessment	Boys with Duchenne Muscular Dystrophy	Yes	No	No
VDMB	Children (general)	Yes	No	Yes

Types of Telehealth Delivery
The majority of studies (n=26) employed asynchronous methods for their assessment with the assessment being video recorded and scored afterward, this includes the GMA, Assessment of Motor Repertoire 3-5 months, IMP, VDMB, GMPM, AIMS.[15,25-27,29,30,32-41,43-50,52-55,60] Ricci & Reidy and Zischke et al commented on and reviewed studies that used asynchronous and synchronous methods respectively. All the studies of the GMA and IMP used asynchronous methods as this is inherent in the assessments. The remaining four studies employed synchronous methods for scoring the North Star Ambulatory Assessment, GMFM-88, HINE and MABC-2.[28,31,42,51]

Quality of Included Articles

The CCAT scores ranged from 0% to 88%. A common issue was sampling with only one study reporting how it arrived at its sample size.[41] Consequently it is not possible to generalise results of the remaining assessment tools. One study of the GMA used a video database of infants from multiple time points and the investigators could not report on quality or conduct of those that took the video recordings.[54] Nicola et al studied healthy children when the face-to-face MABC-2 validity and reliability testing is for children with motor impairments.[31] Gavazzi et al and Fyfe et al reported validity and reliability testing for the GMFM-88 for people with leukodystrophy and Rett's syndrome respectively, however the target populations are children with Down Syndrome or children with Cerebral Palsy.[27,28,59.] Ethics and methodology were other common issues found by using the CCAT. Emery et al reported that methodology was limited by the Covid-19 pandemic as there was only opportunity to conduct assessments remotely. Clinical significance was not always reported with thirteen studies that did not report clinical significance using confidence interval or p values.[15,26,27,30,38-40,43,46,47,51,52,55] However, for Schlichting et al, Maitre et al was not necessary due to outcomes measured (ease of use and adverse outcomes), nor for Spittle et al as it was a protocol and for Ricci & Reidy as the paper was a commentary only.[15,47,51,55]

DISCUSSION

This scoping review provides an overview of the evidence around the use of gross motor assessments undertaken via telehealth. The included studies were mainly validity and reliability studies (n=16). The studies used inconsistent methods of reporting reliability and validity with ICCs, Lin's concordant coefficient, Bland Altman Limits of Agreement, Cohen's Kappa and Spearman's Rho correlation coefficient all being used. Outcomes to support feasibility were parent or clinician reported ease of use, reports of adverse outcomes and percent of telehealth sessions missed.[5,42,47,51,60] Only one study of the GMA justified its sample size.[41] The GMA assessment for children with Cystic Fibrosis reported having a comparison group of healthy controls.[49]

Asynchronous assessments were more prevalent in this review than synchronous. The potential reasons are varied. It is possible that assessments were recorded so they could be assessed for inter-rater and intra-rater reliability more easily with the child only having to sit through one assessment. It is also possible that since it is easy to record a telehealth assessment and does not require additional work or equipment that telehealth providers felt more confident in the results of the assessment if they could watch it as many times as needed. Mahnke et al report in their study of asynchronous paediatric telehealth the benefit of asynchronous telehealth is that the child can access greater expertise than their primary provider can offer without the need to travel.[63] The primary provider can access assistance and a second opinion without the child having to sit through multiple appointments or assessments. This is relevant to gross motor assessments where the scorer requires specialist training. The GMA, for example, can be recorded by a parent and scored by a trained scorer whose location is not easily accessible to the child or family.[39] Additionally, parents can record the assessment at a time when the child is awake and compliant.

Limitations

Limitations of this review include all authors speaking only English, resulting in English language studies only. Search terms may have been missed but this was minimised by liaising with JCU librarians on the search strategy. It was difficult to apply the CCAT to more technical, proof of concept studies, particularly computer-based video analysis studies of the GMA, because the tool was not developed with these types of studies in mind.[38] This difficulty was overcome by using three reviewers (CG, AJ & MC) for scoring and agreeing on the CCAT score

CONCLUSIONS

Gross motor assessment tools investigated for use via telehealth were the AIMS, the Assessment of Motor Repertoire 3-5 months, the GMA, the GMFM-88, the GMPM, the HINE, the IMP, the MABC-2, the North Star Ambulatory Assessment and the VDMB. The AIMS, the GMFM-88 and the Assessment of Motor Repertoire 3-5 months had inter-rater reliability, intra-rater reliability and validity reported. The GMA was the only tool to be assessed for sensitivity, specificity, positive predictive value and negative predictive value. Given that this is a diagnostic assessment this was appropriate.

Feasibility was reported through the number of adverse events, perceptions of ease of use and number of telehealth sessions missed. The five studies that reported being easy to use via telehealth were the GMFM, AIMS, HINE, GMA and North Star Ambulatory Assessment.[15,42,47,51,60]

This review identifies many areas for additional research including comprehensive validity and reliability testing for the GMA, GMPM, HINE, IMP and MABC-2, testing on target populations for the MABC-2 and the GMFM-88, and testing with justified sample sizes for all assessments excluding the GMA. Rural populations should be investigated as sample populations when conducting validity and reliability testing as it is likely this is the population gross motor assessments via telehealth will be practically used on. Feasibility should be more thoroughly investigated, particularly in relation to rural populations who are the

group identified by the review authors as the most likely beneficiaries of more widespread use of telehealth for gross motor assessments.

Funding
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Conflicts of Interest
The authors declare there are no conflicts of interest.

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Appendix 1: Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	1-3
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	3
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	3
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	3-4
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	4
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	4
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	3
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	4
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	7-13
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	4
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	5
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	6
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	7-13
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	7-13
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	7-13
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	7-13

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	19
Limitations	20	Discuss the limitations of the scoping review process.	18
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	19
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	19

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.
* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.
† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).
‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.
§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

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