Systematic Review

A Systematic Review of Self-Reported Pain Rating Scales for Children and Adolescents

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Background: Pain assessment in pediatric populations via self-report tools pose unique challenges given the patients' cognitive abilities and developmental status; however, the accurate measurement of pediatric pain is crucial in improving patient outcomes.

Objectives: This review evaluates recent medical literature to better understand potential correlations and concordance exhibited by self-reported pain intensity assessment tools for children and adolescents in addition to assessing the viability and utility of electronic delivery modalities.

Study Design: Systematic review without meta-analysis.

Methods: An online database search was conducted utilizing PubMed/MEDLINE, EMBASE, and Google Scholar. Screened studies were limited to documents published between June 2004 and January 2022. All included studies were published in English, focused on pediatric self-report scales, and included comparisons of at least 2 different scales or various delivery modalities of the same scale. Risk of bias was assessed per the Cochrane Systematic Review Handbook.

Results: A total of 19 articles were selected for inclusion in this review. The findings indicate that pain scales incorporating visual aids, such as faces and colors, exhibit strong correlations with other pain assessment scales. However, discriminating between pediatric pain scales is still more nuanced, as evidenced by the contrasting paired correlation results shown between 2 similar face-based scales, underscoring the potential differences in the perception of fine details included within the visuals.

Limitations: Limitations of this review include its focus on specific pain intensity metrics in children aged 3 to 18 without consideration of cognitive age or inclusion of articles about both acute and chronic pain. Study section and publication bias may have impacted the general findings, as is true of any systematic review.

Conclusions: Self-report pain scales that include visual aids such as colors and facial features may allow for the better assessment of pediatric pain than do pain scales without visual aids; however, additional research is required to fully elucidate the effects of such elements. This systematic review suggests that a universal, emoji-based electronic pain scale may enhance reporting accuracy and allow personalization for pediatric patients from various backgrounds.

Key words: pain, pain diagnosis, pain intensity, pain rating, pain scales, pain assessment, children pain, adolescent pain

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Accurate pain assessment is crucial in pediatric populations due to the negative outcomes associated with untreated pain. These outcomes include prolonged hospitalization, increased healthcare costs, and decreased quality of life (1). Chronic pediatric pain has been suggested to wield a negative impact on emotional and behavioral states, leading to anxiety, depression, and post-traumatic stress disorder (1,2). Poorly managed pain can lead to chronic pain, sleep disturbances, and delayed recovery (2,3). Beyond these consequences, Groenewald et al have estimated that chronic pain in the pediatric population costs an annual $19.5 billion in the United States (4).

The predicament of pediatric pain is particularly interesting in light of modern clinical advancements in pain management. It has been reported 40% of hospitalized children continue to experience moderate to severe pain despite a plethora of innovations (5). To properly address the pain of pediatric patients, clinicians must be able to assess the intensity of pain. Three distinct methods for measuring pain intensity include physiological means, behavioral means, and self-reporting. The last is used most frequently , since it is considered the most precise and reliable measure of pain intensity, regardless of the patients' demographic backgrounds (6,7).

Unfortunately, for reasons based on their age, cognitive ability, or developmental status, children may not always be able to communicate their pain effectively via the self-report method (2). It should also be recognized that the subjective and multidimensional aspects of pain make pediatric pain research, assessment, and management extremely difficult (2,3). Health care providers rely on age-appropriate pain assessment tools such as the Color Analog Scale (CAS), Faces Pain Scale (FPS), Numeric Rating Scale (NRS-11), visual analog scale (VAS), and Wong-Baker FACES® Pain Rating Scale (FACES®), which are some of the most commonly used pain scales in pediatric populations (2,8).

The aim of this article is to evaluate and compare the level of agreement and potential correlations among self-reported pain scales for pediatric patients. This article will also assess electronic versions of pediatric pain scales and compare these scores to those of more traditional delivery modalities. By contrasting the different pain scales, this article provides an updated review meant to educate health care professionals about the different pain intensity metrics available and each metric's relative advantages and disadvantages. We expect that this knowledge may allow health care providers to choose the most appropriate pain scale for their pediatric patients, resulting in better pain management and potentially improved outcomes.

Methods

Study Search Methodology

The search methodology for identifying studies that described scales for rating pain intensity in children and adolescents is described below. Online searches were conducted in the databases PubMed/MEDLINE, EMBASE, and Google Scholar for studies published between June 2004 and January 2022. The search phrases and keywords used were: ("pain intensity" OR "pain intensity scales" OR "intensity scales" OR "pain rating" OR "pain rating scales" OR "rating scales") AND ("comparison of" OR "comparison of pain" OR "intensity assessment" OR "assessment of pain" OR "pain assessment") AND ("pediatric" OR "child" OR "adolescent" OR "children" OR "young"). The search was limited to studies conducted on humans, specifically children and adolescents under the age of 18, and published in English (Fig. 1).

Study Selection and Data Screening

A 2-stage screening process was employed to identify studies that met this review's inclusion criteria and distinguish those studies from articles that met the exclusion criteria. Two research assistants independently screened papers based on predetermined eligibility criteria. Duplicate articles identified through manual comparison were removed from the EMBASE results. Inclusion criteria comprised explicit comparisons of self-report pain rating scales as well as studies that compared 2 types of the same scale, such as simplified or electronic versions. Case reports, editorials, letters, commentaries, overviews, conference abstracts, and reviews or meta-analyses were excluded from the prerent review. Clinical studies that used physiological or observational scales, studies that involved adult or nonhuman patients, studies not in English, and studies published before 2004 were excluded. References from eligible papers were cross-checked, and the "Related Articles" and "Cited by" functions in Google Scholar were utilized to identify additional qualified studies. Individual study risk of bias was assessed via appropriate tools from the Cochrane Handbook for Systematic Reviews of Interventions (9).

Results

Eligible Studies

A total of 979 studies were identified through database searches, 528 from PubMed/MEDLINE and 451 from EMBASE. After exclusion criteria were applied, the number of candidate studies was reduced to 133, including 75 from PubMed/MEDLINE and 58 from EMBASE. A review of abstracts further reduced the number of studies to 8 from PubMed/MEDLINE and 2 from EMBASE for a total of 10 studies. After the references in these studies were examined via the "Related Articles" and "Cited by" functions in Google Scholar and exclusion criteria were applied again, 9 additional studies were identified as eligible. Therefore, a total of 19 studies were analyzed for this review. Twelve of these studies directly compared correlations or the level of agreement among various scales, while 4 of the included studies delved into contrasting electronic and traditional versions of those pain scales. The final 3 of the included studies compared the scales via additional metrics such as reproducibility, suitability for age groups, and feasibility (Fig. 1).

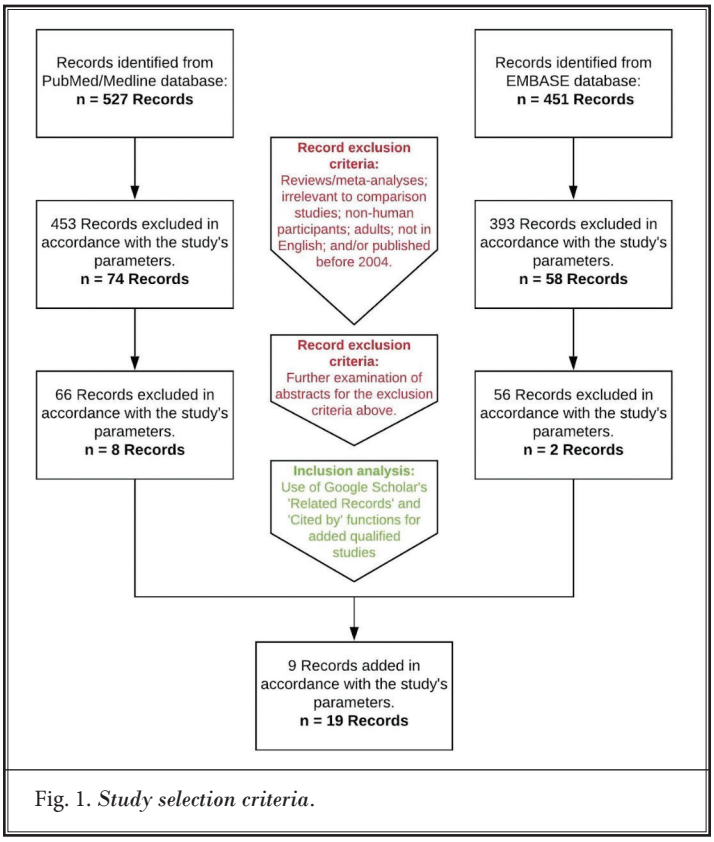

Fig. 1. *Study selection criteria.*

Identified Self-Report Pediatric Pain Scales

The studies included in this review utilized a total of 8 pain rating scales, listed here in alphabetical order: the CAS, the Faces Pain Scale-Revised (FPS-R), NRS-11, the Simplified Concrete Ordinal Scale (S-COS), the Simplified Faces Pain Scale (S-FPS), the 6-point verbal rating scale (VRS-6), the VAS, and FACES®.

The CAS measures 10 cm in height and 2 cm in width and features a wedge-shaped figure with a color gradient on one end and a numerical scale with a mobile slider on the other (Fig. 2a) (10). The FPS-R is a simplified version of the FPS, revised by Hicks et al to include 6 faces and a tailored 0-2-4-6-8-10 scoring scale (Fig. 2b) (11,12). The NRS-11 is a horizontal line bearing whole numbers from 0 to 10, allowing patients to rate their pain intensity from "no pain at all" to "worst pain possible" (Fig. 2c) (13). The S-COS includes 3 images of play blocks, all of the same color and size, progressively being stacked on top of one another to demonstrate increasing levels of pain (Fig. 2d) (14). Somewhat similarly, the S-FPS includes 3 faces of the same size, depicting increasing levels of pain moving from left to right (14). The VRS-6 is used for the categorical classification of pain and asks patients to select the word for a list that best represents their current pain (15). The VAS is a 10 cm line on which patients place a mark to indicate their pain intensity, with the leftmost end indicating no pain and the rightmost end indicating the worst pain imaginable. This scale is often depicted adjacent to the NRS-11 for comparison (Fig. 2c) (13). Finally, the FACES® was created to help children express their pain, featuring 6 faces ranging from a happy, smiling face to a tearful, sad face symbolizing the most pain imaginable (16). Children choose the face that best describes their pain from among these options (Fig. 2e).

Comparison of Self-Report Pediatric Pain Scales

An overview of sample size and population, objectives, findings, conclusions, and preference for scale use is summarized in Table 1. Twelve studies concentrate on exploring correlation and concordance, whereas 4 studies specifically examine differential delivery modalities (Table 1). Among the studies that reported potential correlations or levels of agreement between or among different scales, 7 conducted direct comparisons of 2 pain scales, while 3 broadened their scopes to evaluate 3 pain scales.

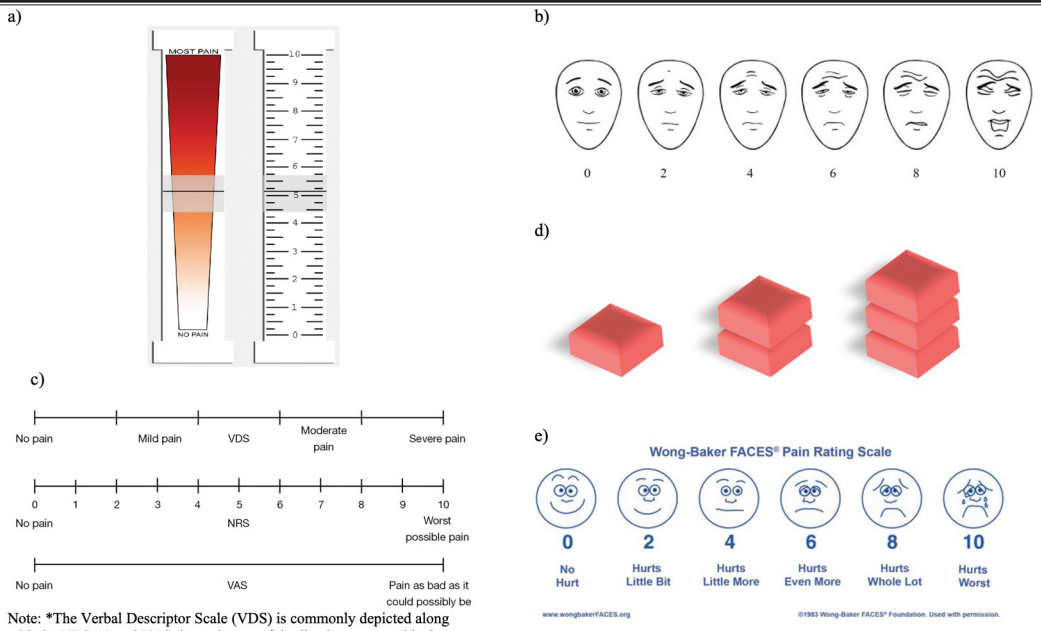

Fig. 2. *a) Color analog scale (CAS) (9); b) Faces Pain Scale-Revised (FPS-R) (10,11); c) visual analog scale (VAS), Numeric Rating (NRS-11), and Verbal Descriptor* (VDS) Pain Scales12; d) Simplified Concrete Ordinal Scale; e) Wong-Baker FACES® Pain Rating Scale (15).*

Additionally, 2 more studies delved into relationships among 4 scales, and one study focused on reviewing and cross-calibrating 6 pain rating metrics (Table 1).

CAS Paired Scale Analysis

In reviewing the different studies, paired scale analyses demonstrated strong relationships in nearly all studied combinations (Table 2). As far as the CAS-VAS pair was concerned, the strongest relationships were reported for patients ages 6-8 by Sánchez-Rodríguez et al (r = 0.89) and for patients 6-17 years old by Le May et al (r = 0.92) (17,18). Both of these studies also scrutinized the concordance between the CAS and VAS. Interestingly, their results contradicted each other: Sánchez-Rodríguez et al reported low concordance, whereas Le May et al noted that scores from the 2 scales could be contained by a single 95% confidence interval (17,18). Another study that tested the concordance of CAS-VAS pairs, this time in patients ages 8-18 with moderate to severe acute abdominal pain, was performed by Bailey et al. The study concurred with one conducted by Le May et al (18) in stating the CAS and VAS appropriately agreed with each other. Clinically, the Le May et al (18) and Bailey et al (19) studies suggest the CAS and VAS serve as effective and interchangeable measures of acute pediatric pain across wide age distributions, while the Sánchez-Rodríguez et al study disputes the interchangeability of these scales within a narrower age range (Table 1). Those reviews all employed methods to reduce the influence of repeat measurements and earned low risk of bias, given the studies' designs.

Paired analysis of the CAS and FPS similarly produced multiple strong correlations for the 5–9-year-old and 10–15-year-old age groups in Perrott et al (20) (r = 0.84, r = 0.91) . The study suggested that scales utilizing facial expression may be the most appropriate option when assessing pain in pediatric patients (Table 1). Intriguingly, the strength of the CAS-FPS correlation appeared to diminish as the age range widened, with Goodenough et al (21) reporting the lowest correlation coefficient for this pair (r = 0.75) in an analysis of 4-16-year-olds. Despite this observation, Goodenough et al still recommended both the CAS and FPS as pediatric pain metrics and noted that the facial features enhanced the ease of use (Table 1). Again, both studies attempted to reduce the risk of bias, so, given the study designs, that risk was low.

Three of the selected studies included CAS-FPS-R comparisons, with Sánchez-Rodríguez et al observing significant correlations between these scales in

Table 1. *Studies comparing pain rating scales for children that were explained and reviewed in the present study.*

Investigator(s), Title, and Date	Sample Size and Population	Objectives	Findings	Conclusion, Preference for Scale Use
Correlation and Concordance Studies				
Bailey et al, 2007 (19)	87 children in ED department (age 8-18 years)	To determine the agreement among pain scales (VAS, CAS, FACES®*, and VNS†) in children with acute abdominal pain suggestive of appendicitis in a pediatric emergency department (ED).	Only the VAS and the CAS have acceptable agreement in children with moderate to severe acute abdominal pain. In particular, the verbal numeric scale is not in agreement with the other evaluated scales.	The VAS and the CAS have acceptable agreement for children with moderate to severe acute abdominal pain and are preferred.
Garra et al, 2009 (26)	120 patients (age 10-15 years)	To validate the FACES® for children presenting to the ED with pain by identifying a corresponding mean value of the VAS for each face of the FACES®; to determine the relationship between the FACES® and VAS.	Agreement between the FACES® and VAS was excellent (q = 0.90; 95% confidence interval (CI) = 0.86 to 0.93).	The VAS was found to have an excellent correlation for older children with acute pain in the ED and had a uniformly increasing relationship with FACES®.
Goodenough et al, 2005 (21)	82 patients (age 4-16 years)	To compare and cross-calibrate 6 self-report pain rating scales for children.	Each of the 6 scales correlated highly with one another. Both younger and older children found facial-expression-based scales easier to use than the others. The FPS and the CAS had the highest correlations with the composite score of all scales.	FPS and CAS are recommended.
Khatri et al, 2012 (27)	180 patients (age 3-14 years)	To compare pain measurement techniques, VAS and FACES®, among Delhi children aged 3 to 14 years undergoing dental extraction.	Pain threshold tended to decline, and the self-management of pain became more effective with increasing age. The 2 pain scales were correlated with one another.	FACES® was found to be more sensitive than the VAS. To reiterate, pain threshold tended to decline, and pain management became more effective with increasing age.
Le May et al, 2018 (18)	456 children ED patients (age 6-17)	To determine and compare the psychometric properties of 3 self-report pain scales (VAS, FPS-R, CAS) commonly used in the pediatric ED.	Pair correlations; VAS/FPS-R = 0.78, VAS/CAS = 0.92, CAS/FPS-R = 0.79 Only the VAS and the CAS showed acceptable agreement ([95% CI]: -1.73 to 1.75)	The scales demonstrated good psychometric properties for pediatric ED patients with acute pain. The VAS and CAS showed a strong convergent validity, while FPS-R was not in agreement with the other scales.
Myrvik et al, 2016 (25)	28 patients (8-18 years old, mean ± SD age 14.65 ± 3.12 y) receiving pain interventions within the ED	To compare VAS and NRS-11 pain severity ratings in children with sickle cell disease (SCD) and thus identify the relationship and agreement between the ratings on those pain scales.	The correlation between the VAS and NRS-11 was significant for the initial pain assessment (rs = 0.88, $P < 0.001$) and across all pain assessments (rs = 0.87, $P < 0.001$).	The VAS and NRS-11 are similar but cannot be used interchangeably when assessing self-reported pain in patients with SCD.
Newman et al, 2005 (24)	122 Thai children, of whom half were infected with HIV	To assess validity of 3 commonly used rating scales (VAS, FACES®, FPS-R).	The 3 pain scales were all significantly correlated with one another on overall analysis.	Children had more difficulty understanding the use of the VAS than that of the FACES® or FPS-R.
Perrott et al, 2004 (20)	90 pediatric elective surgery patients (in 2 age groups: 5-9 and 10-15 years)	To explore whether global unidimensional self-report pain scales based on facial expressions help children separately estimate the sensory and affective magnitude of postoperative pain.	Ratings on the FPS correlated more highly with analog scale ratings for intensity than with those for unpleasantness, whereas ratings on the FAS correlated more highly with those on the analog scale for unpleasantness than with those for intensity.	Facial-expression scales appear to be the most appropriate choice among currently available measures for helping children over a wide age range to estimate the separate sensory and affective components of their pain in a postoperative context.

Table 1 cont. *Studies comparing pain rating scales for children that were explained and reviewed in the present study.*

Investigator(s), Title, and Date	Sample Size and Population	Objectives	Findings	Conclusion, Preference for Scale Use
Sanchez-Rodriguez et al, 2012 (17)	126 (age 6-8 years)	To determine the one-dimensionality of 4 widely used self-report scales for measuring the intensity of pediatric pain and the agreement among them	The VAS, CAS, verbal NRS-11, and FACES® pain rating scales measured one common factor but were not concordant.	The scales in this study cannot be used interchangeably to measure pediatric pain intensity. The NRS-11 produces the highest scores of pain intensity among the 4 scales, and the VAS produces the lowest.
Subhashini et al, 2008 (22)	181 children (age 6-12 years)	To compare the FPS-R and CAS among children aged 6-12 years undergoing selected procedures	There was a significant positive correlation (r = >0.8) between the pain scales.	Both the FPS-R and the CAS were appropriate tools for assessment of pain among children aged 6-12 years. The parents and health care professionals are reliably able to assess procedure-related pain in children by using the same pain scales (FPS-R and CAS).
Tsze et al, 2013 (8)	620 children (age 4-17 years)	To determine the psychometric properties (convergent validity, discriminative validity, responsivity, and reliability) of the FPS-R and CAS, and to determine whether the degree of validity varied based on age, gender, or ethnicity.	Pearson correlation was 0.85, with higher correlation in older children and girls. Lower convergent validity was noted in children under 7 years of age. All subgroups based on age, gender, and ethnicity demonstrated discriminative validity and responsivity for both scales. Reliability was acceptable for both the FPS-R and CAS.	The FPS-R and CAS overall demonstrate strong psychometric properties in children aged 4 to 17 years and among subgroups based on age, gender, and ethnicity. Convergent validity was questionable in children under 7 years of age.
Tsze et al, 2018 (23)	733 children (age 4-17 years)	To determine the validity and reliability of the NRS-11 against FPS-R in children presenting to the ED.	Supported use of NRS for ages 6-17. Agreement between the NRS-11 and FPS-R was limited in Spanish-speaking and Black or African American children.	NRS-11 not recommended for use for ages 4 and 5.
Delivery Modality Studies				
Castarlenas et al, 2015 (28)	191 schoolchildren in grades 7-11 (mean age 14.61 years; range 12-18 years)	To examine the agreement between the verbal and the electronic versions of the 11-point NRS-11 (vNRS-11‡ and eNRS-11‡, respectively) when used to assess pain intensity in adolescents; and (2) to report patients' preferences between each of the 2 alternatives.	The limits of agreement at 80% CI fell inside the maximum limit established a priori (scores ranged from -0.88 to 0.94), except for patients in grade 8. The κ -coefficients ranged from 0.79 to 0.91, indicating "almost perfect" agreement. A total of 83% of patients preferred the eNRS-11.	Most of the patients preferred the electronic version of the scale.
Sanchez-Rodriguez et al, 2017 (29)	180 young patients (age 12-19)	The aim of this study was to analyze the validity and agreement of the intensity reports provided by electronic versions of the CAS, VAS, FPS-R, and NRS-11 and their traditional counterparts.	The 4 electronic versions of the scales measured a single factor. All the scales showed a) moderate-to-high convergent validity, b) adequate discriminant validity with fatigue ratings, and c) adequate concurrent validity with pain-catastrophizing ratings. Traditional and electronic versions of the 4 scales are in agreement, at least at the 80% CI.	Pain intensity scores reported with the scales (eNRS-11‡, eFPS-R‡, eVAS‡, eCAS‡) in the Painometer app are valid and concordant with their traditional counterparts, supporting the use of electronic versions of these 4 pain intensity scales with young people.

Table 1 cont. *Studies comparing pain rating scales for children that were explained and reviewed in the present study.*

Investigator(s), Title, and Date	Sample Size and Population	Objectives	Findings	Conclusion, Preference for Scale Use
Sun et al, 2015 (30)	62 patients (age 4-12 years) participated in the FPS-R trial; 66 patients (age 5-18 years) participated in the CAS trial.	To evaluate agreement between Panda† and original paper/plastic versions of the FPS-R and CAS and to determine children's preference for either the Panda or original versions of these scales.	Pain scores obtained with the electronic versions were strongly correlated with the scores obtained using the original tools for both the FPS-R ($r > 0.93$) and the CAS ($r > 0.87$) in the postoperative recovery period.	The Panda smartphone application can be used for self-reported pain scores in lieu of the original FPS-R and CAS pain assessment tools for children aged 4-12 years and 5-18 years, respectively. Overall, more children preferred Panda over the original versions of the FPS-R and CAS.
Wood et al, 2011 (31)	202 pediatric patients, age 4-12 years, mean age 8.3 years	To compare the concordance and the patients' preference between 2 versions (electronic and paper) of the FPS-R and to determine whether an electronic version of the FPS-R could be used by children aged 4 and older.	The overall weighted Kappa was 0.846 (95%CI: 0.795; 0.896). The Spearman correlation between scores of the 2 versions was rs = 0.911 ($P < 0.0001$).	The electronic version of the FPS-R can be recommended for use with children aged 4 to 12, either in clinical trials or in hospitals, to monitor pain intensity.
Additional Studies				
Chaves et al, 2014 (32)	29 children 13 symptomatic (9.79 ± 1.36 years old) and 16 asymptomatic (8.69 ± 0.87 years old).	To compare the levels of reproducibility between two Faces Pain Scales (FPS) of 6 and 4 categories to the assessment of pain intensity on children with and without temporomandibular joint and muscle pain.	Higher levels of reproducibility were verified with the application of the 6-category FPS in both groups and considering symptomatic and asymptomatic as a single group.	The 6-category FPS should be preferred over the 4-category FPS to assess pain intensity on children's orofacial structures.
Miro et al, 2016 (15)	113 youths (mean age = 14.19 years; SD = 2.9)	To explore whether pain rating scales are all equally suitable for youths (aged 8–20) with physical disabilities by comparing the validity of the NRS-11, FACES®, and a 6-point categorical Verbal Rating Scale (VRS-6).	The NRS-11 out-performed both the VRS-6 and in particular the FACES® scale with respect to: (1) the associations with the validity criterion (i.e., pain interference, disability and psychological functioning) and (2) a lack of any moderating effect of age on the association between the measure and the criterion variables.	All the measures were associated positively with each other. The findings support the validity of the NRS-11 for assessing pain intensity in youths with physical disabilities between the ages of 8 and 20 years.
Emmott et al, 2016 (33)	180 3- to 6-year-old children undergoing routine blood collection. 60 (age 3) 60 (age 4) 60 (age 5-6)	To evaluate the validity and feasibility of 2 novel simplified scales (Simplified Faces Pain Scale, S-FPS†; Simplified Concrete Ordinal Scale, S-COS†) for preschool-age children.	The ability to discriminate pain from the absence of pain was improved with S-FPS and S-COS over FPS-R amongst 4-year-olds but not 3-year-olds. Correlation with FLACC was moderate to strong, and cooperation rates were similar for all self-report scales.	The simplified scales can improve and simplify pain assessment for 4-year-olds. Quantitative pain rating remains challenging for 3-year-olds.

Notes: `
*The Wong-Baker FACES® scale is referred to by many initialisms. For simplicity, we have used only "FACES®."
†The verbal numeric scale (VNS), Simplified Faces Pain Scale (S-FPS), Simplified Concrete Ordinal Scale (S-COS), and Panda smartphone application were outside the scope of this review or had minimal comparison studies available.
‡ The prefix e denotes "electronic," and v denotes "verbal."

6–8-year-olds (r = 0.71). Tsze et al and Subhashini et al shared similar findings to the Sánchez-Rodríguez et al study across the 4-17-year-old (r = 0.85) and 6-12-year-old age groups (r = 0.80), respectively (17,18,22). Once again, Sánchez-Rodríguez et al reported low concordance while Tsze et al noted high convergent validity outside of the subgroup exclusively composed of patiets under 7 years old (17,8). Clinically, the Sánchez-Rodríguez et al findings did not support using the CAS and FPS-R interchangeably, whereas Tsze et al suggested both metrics agreed with each other and demonstrated strong psychometric properties (Table 1). Subhashini et al (22) stated that both the CAS and FPS-R were reliable metrics. The respective studies conducted by Sánchez-Rodríguez et al and Tsze et al demonstrated strong methodolical basis and acknowledged limitations, including potential anchor bias in Tsze et al, while Subhashini et al raised some concerns due to the variable use of sedation by patients. Ultimately, such concerns produced low-to-moderate risk of bias, since scores were compared on the level of the individual.

The CAS and NRS-11 pair was also assessed by Sánchez-Rodríguez et al for the 6–8 age range, and statistically significant correlation between the 2 scales was reported (r = 0.79); however, the study reiterated the aforementioned analysis regarding agreement between those scales (17). On this latter point, NRS-11 scores were generally the highest of those on all scales compared by Sánchez-Rodríguez et al for 6–8 year olds, and the scales were not interchangeable in this population (Table 1).

FPS-R Paired Scale Analysis

Paired scale analyses that used the FPS-R exhibited a similar pattern of correlation with other pain scales. Specifically, FPS-R-NRS-11 pair comparisons in the Sánchez-Rodríguez et al and Tsze et al studies reported strong correlations in the 6-8 and 8-17-year-old age groups, respectively (r = 0.75, r = 0.95) (17, 23). Interestingly, the latter study concluded that the convergent validity of the FPS-R-NRS-11 pair was limited in the 4–7-year-old age group (r = 0.68) but high in 8–17-year-olds (r = 0.92), while Sánchez-Rodríguez et al again noted strong correlation without concordance between the scales (17,23). Translating these results into clinically-relevant information, although the FPS-R and NRS-11 were both valid but not interchangeable for the 6-8 age group studied by Sánchez-Rodríguez et al, the same scales were interchangeable with a wider range of ages in the Tsze et al study (Table 1). Notably, Tsze et al recommended against the use of the NRS-11 for the 4- and 5-year-olds included in their study (Table 1) (23). The study conducted by Sánchez-Rodríguez et al has already been graded as having a low risk of bias. Tsze et al did acknowledge potential bias secondary to lack of blinding, which increased their risk of bias to moderate.

Tsze et al also determined decreased agreement between the NRS-11 and FPS-R among patients of non-Hispanic black race/ethnicity and children who spoke Spanish as their primary language. Among non-Hispanic black children, 72.7% (95% CI: 62.9–81.2%) had differences of fewer than 2 out of 10 points between the FPS-R and NRS-11, compared to 97% (95% CI: 84.2–99.9%) of white children (23). These results categorized non-Hispanic black children as the only racial/ethnic subgroup that did not meet the study's 80% threshold for strong agreement between the 2 scales. Likewise, 74.3% (95% CI: 62.4–84.0%) of primarily Spanish-speaking children had differences of fewer than 2 out of 10 points between the FPS-R and NRS-11, compared to 82.8% (95% CI: 79.7–85.6%) of primarily English-speaking children (23).

Continuing to delve into the analyses of the FPS-R, Newman et al and Sánchez-Rodríguez et al both contrasted the FPS-R with the VAS with differing conclusions. Sánchez-Rodríguez et al reported a strong FPS-R-VAS correlation within the 6-8 age group (r = 0.73) while the Newman et al study covered the 4-15 age group and was the only paired analyses in the included studies that did not support a significant correlation between the 2 tested scales (r = 0.67) (17,24). As for concordance between those scales, the data collected by Sánchez-Rodríguez et al failed to support noteworthy agreement, while Newman et al reported moderate agreement (17,24). Beyond the correlation and concordance data, Newman et al found the VAS was more difficult for pediatric patients to understand than was the FPS-R (Table 1) (24).

Newman et al (24) continued to assess correlations of pain scales by focusing on the relationship between FPS-R and FACES®. In contrast to the FPS-R-VAS relationship reported in the same article, the FPS-R-FACES® pair produced a correlation coefficient above the significance threshold (r = 0.79), and the 2 face-based scales demonstrated stronger agreement. Both the FACES® and FPS-R were easier for pediatric patients to understand than was the VAS (Table 1) (24). Risk of bias for the Newman et al study was graded as moderate due to lack of limitations within the discussion.

VAS Paired Scale Analysis

Finally, the selected studies included VAS-NRS-11 and VAS-FACES® paired analyses. The VAS-NRS-11 pair displayed correlation coefficients above the significance threshold for the 6-8 and 8-18 age groups (r = 0.74, r = 0.88) (17,25). The former study demonstrated a low risk of bias, and the latter was graded as moderate due to sample size. Despite the reported correlation coefficients, both VAS-NRS-11 studies stated the scales could not be used interchangeably due to low levels of agreement (Table 1) (17,25).

The paired VAS-FACES® analysis performed by Newman et al illustrated yet another significant correlation (r = 0.70) and moderate agreement (24). A separate study published by Garra et al focused on 10-15-year-olds reported a significant VAS-FACES® Spearman agreement (*P* = 0.90 [95% CI: 0.86 to 0.93]) (26). The VAS and FACES® were found to have excellent correlation and agreement in older children experiencing acute pain in the emergency department, demonstrating a uniformly increasing relationship with each other (Table 1). The associated risk of bias was assessed as low. Khatri et al (27) validated the VAS-FACES® correlation from the aforementioned studies and further claimed that FACES® was more sensitive than VAS. Khatri et al (27) also reported that as pediatric patients aged, their pain thresholds declined and patients became more adept at managing their own pain (Table 1). The associated risk of bias in that study was moderate-to-severe, since the statistical analysis methodology included in it was limited.

Table 2. *Studies that reported correlations between pain rating scales in children (r represents Pearson correlations, ρ represents Spearman correlations, and CI denotes confidence interval).*

Pain Scales	Reference	Statistics	Age														
			4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
CAS & VAS	Sanchez-Rodriguez et al, 2012	r = 0.89			•	•	•										
	Le May et al, 2018	r = 0.92			•	•	•	•	•	•	•	•	•	•	•	•	
	Bailey et al, 2007	95% CI Agreement					•	•	•	•	•	•	•	•	•	•	•
CAS & FPS	Perrott et al, 2004	r = > 0.84		•	•	•	•	•									
	Perrott et al, 2004	r = 0.91							•	•	•	•	•	•			
	Goodenough et al, 2005	r = 0.75	•	•	•	•	•	•	•	•	•	•	•	•	•		
CAS & FPS-R	Sanchez-Rodriguez et al, 2012	r = 0.71			•	•	•										
	Tsze et al, 2013	r = 0.85	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
	Subhashini et al 2008	r = > 0.80			•	•	•	•	•	•	•						
CAS & NRS-11	Sanchez-Rodriguez et al, 2012	r = 0.79			•	•	•										
FPS-R & NRS-11	Sanchez-Rodriguez et al, 2012	r = 0.75			•	•	•										
	Tsze et al, 2018	r = 0.92					•	•	•	•	•	•	•	•	•	•	
FPS-R & VAS	Newman et al, 2005	r = 0.67	•	•	•	•	•	•	•	•	•	•	•	•			
	Sanchez-Rodriguez et al, 2012	r = 0.73			•	•	•										
			•	•	•	•	•	•	•	•	•	•	•	•			
VAS & NRS-11	Sanchez-Rodriguez et al, 2012	r = 0.74			•	•	•										
	Myrvik et al, 2016	r = 0.88					•	•	•	•	•	•	•	•	•	•	•
VAS & FACES®	Newman et al, 2005	r = 0.70	•	•	•	•	•	•	•	•	•	•	•	•			
	Garra et al, 2009	ρ > 0.9							•	•	•	•	•	•			

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A subset of studies specifically investigated the electronic administration of the CAS, FPS-R, VAS, and NRS-11 and compared it to the nonelectronic administration thereof.

Casarlenas et al (28) examined the level of agreement between verbally and electronically delivered versions of the NRS-11 in 191 adolescents ages 12 to 18. The analysis included in the study produced an overall κ-coefficient of 0.813, representing an "almost perfect" agreement between the verbal NRS-11 and the electronic NRS-11. Interestingly, when subgroups defined by individual academic classes were analyzed, patients in grade 8 demonstrated the lowest level of agreement between the 2 delivery modalities, with a κ-coefficient of 0.786. This agreement was still classified as "substantial." When patients were asked to indicate a preference for a delivery modality, 83% selected the electronic version. Risk of bias was graded as low-to-moderate for this study, given the potential for memory of prior assessments to influence repeat scoring.

Sanchez-Rodriguez et al (29) studied the validity of and level of agreement among electronic and traditional versions of the CAS, VAS, FPS-R, and NRS-11 in 180 adolescents ages 12 to 19 using the smartphone application Painometer. The results from this study suggest that electronic versions of each scale are valid and, more importantly, that electronic scores agree with traditional scores for all scales when using an 80% confidence interval. All scales showed moderate-to-high convergent validity, adequate discriminant validity with fatigue ratings, and adequate concurrent validity with pain-catastrophizing ratings, supporting the use of electronic versions of those 4 pain metrics in pediatrics (Table 1). This study presented no data on delivery modality preference and possessed a low risk of bias overall.

Sun et al (30) utilized the smartphone application Panda to record postoperative pediatric pain scores using FPS-R and CAS to ultimately evaluate the level of agreement between electronic and traditional delivery modalities. Sixty-two patients ages 4 through 12 were assessed via the FPS-R and demonstrated strong correlations between its electronic and traditional versions ($r > 0.93$). Similarly, 66 patients ages 5 through 18 in the CAS wing of the study demonstrated strong correlations between the electronic and traditional versions ($r > 0.87$). Both groups of postoperative pediatric patients preferred the electronic versions of the pain scales. Hence, the Panda smartphone application could be utilized for pediatric self-report pain assessment using the FPS-R and CAS metrics (Table 1). Repeat measurements were conducted on intervals that might have permitted some degree of unreported confounding. For that reason, the risk of bias was judged to be moderate.

Wood et al compared level of agreement and delivery method preference using FPS-R in a population of 202 pediatric patients ages 4 through 12 (31). This study reported an overall weighted κ of 0.896 (95% CI: 0.795-0.896) and Spearman correlation of 0.911 ($P < 0.0001$). The overall difference between the electronic and traditional versions was approximately 0.1 out of 10 points, which did not translate to a statistically or clinically significant gap. The electronic version was preferred by 87.4% of the patients in the study, which indicated a preference. Therefore, this study recommended the electronic FPS-R for use in pediatric populations ages 4 through 12 in the context of clinical trials or inpatient pain monitoring (Table 1). The study design possessed a low risk of bias.

Additional Studies

The studies conducted by Chaves et al, Miro et al, and Emmott et al included in this review investigated intrascale reproducibility as well as the feasibility and suitability of scales within certain populations (15,32,33).

Chaves et al (32) expanded on the analysis of the FPS-R outlined above by contrasting the reproducibility of 2 versions of this scale, which consisted of either 4 or 6 faces. The results of this study cited increased reproducibility when using the 6-face FPS-R and recommended a preference for this scale in pediatric populations (Table 1) (32). Low-to-moderate risk of bias was assessed due to the potential for sampling bias within the study.

Miro et al (15) tested the suitability of NRS-11, VRS-6, and FACES® for pediatric patients with physical disabilities. While each of the scales demonstrated a positive association with the others, this study found that NRS-11 possessed enhanced validity within this patient population. Specifically, the NRS-11 outperformed the VRS-6 and FACES® with respect to associations with pain interference, disability, and psychological functioning. Moreover, the authors noted that the NRS-11 and VRS-6 did not possess significant correlation to the age of the patient (Table 1). The risk of bias associated with this study is low-to-moderate due to multiple potential confounding variables.

Finally, Emmott et al (33) studied the feasibility of using S-FPS and S-COS in preschool-aged children undergoing routine blood collection. The study reported that simplified scales allowed 4-year-old patients to better differentiate between pain-free versus experiences of pain. Unfortunately, similar findings were absent in the subgroup of 3-year-old patients. Nevertheless, the simplified self-report scales produced moderate-to-strong correlation to the Face, Legs, Activity, Cry, and Consolability assessment tool, an observer-based pain metric, with Spearman coeffecients of 0.72 for S-FPS and 0.62 for S-COS (33). Overall, the simplified scales may be able to improve pain assessment for 4-year-old patients, but similar metrics are still challenging for 3-year-olds (Table 1). There was moderate risk of bias associated with this study, since research assistants were not blinded and multiple confounding variables were unable to be addressed.

Discussion

Previous similar reviews have examined the interpretive consistency of unidimensional pain intensity scales in children and adolescents. Others have investigated which self-report pain intensity measures are most suitable for specific pediatric populations, based on cognitive development status or cultural considerations (34-38). Moreover, additional reviews have explored the possibility of developing a universal, evidence-based approach to select appropriate pain assessment scales for different populations (39,40). The present review, therefore, augments and updates the current literature reviewing pediatric pain scales. Ultimately, a thorough analysis of the included studies suggests a wide variety of pain intensity scales may be clinically appropriate for use within pediatric populations due to strong correlations across multiple metrics. However, not all scales demonstrate high levels of agreement with one another and therefore cannot be used interchangeably.

In some of the comparisons above, various studies seemed to contradict the findings of analogous research. For example, Sánchez-Rodríguez et al reported a low concordance between the CAS and VAS while Le May et al and Bailey et al noted scores from the 2 scales could be contained by a single 95% confidence interval. This disagreement and others similar to it throughout this review are likely secondary to investigating these scales in the context of different populations. In the scenario described above, the age range of the patients in the Sánchez-Rodríguez et al (17) study was smaller than that of either Le May et al (18) or Bailey et al (19). The differences in the studies' conclusions can likely be attributed to this dissimilarity.

Regarding the utility of pain scales for specific age ranges amongst pediatric and adolescent populations, the CAS consistently correlated highly with other scales across all age groups, with the highest correlations found between CAS and VAS and between CAS and FPS. Therefore, the use of color as seen in the CAS may be beneficial for a wide range of patients. In addition to the possible usefulness of color, previous studies have also documented a preference for face-based scales across all pediatric age groups (20,21). This preference seems logical, since it capitalizes on the innate human understanding and recognition of facial expressions. Face-based scales do not require an understanding of numeric or spatial relativity; instead, these scales rely on the natural abilities of the child and may eliminate the need to "translate" pain into a number, position in space, or color.

Interestingly, the current review did note a relatively low correlation (r = 0.67) between FPS-R and FACES®, 2 pain scales that utilize the same medium of 6 human faces. This observation is counterintuitive, given the aforementioned preference for face-based scales across all age groups. These findings may suggest that the presence of fine, nuanced details within the faces influences patients to rank pain differently. When the FACES® and FPS-R are compared, the latter has a more realistic face shape in addition to folds in the forehead and chin that resemble levels of grimace (Fig. 2b). The results of the present review call for additional research to determine if such nuanced details within the face-based pain scales may truly contribute to the differential reporting of pain intensity in pediatric populations. The current review also included a study that concluded that a 6-face scale was preferred over a similar 4-face scale. This finding encourages future research endeavors focused on the optimization of such scales for pediatric populations.

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In addition to contrasting the correlation and concordance of pain intensity scales, the present review also investigated the literature regarding the comparative effectiveness between electronic pain intensity scales and their traditional counterparts for children and adolescents. Based on an analysis of several studies, the present review found that electronic pain scales were equivalently valid to paper scales

(28-31,41). Additionally, the use of electronic pain diaries or "e-diaries" has been found to be particularly beneficial in chronic pediatric pain reporting due to the potential for automated scheduling reminders and improved patient-provider communication, resulting in better tracking of therapeutic efficacy (28,29,42,43). In general, pediatric patients appear to prefer electronic delivery modalities over the traditional methods, which provides a fascinating avenue for both clinicians and researchers to improve their connections with children.

With these results under consideration, the current review contemplates the potential of emojis in pediatric pain assessment, building on recent JAMA publications (44,45). Universal emojis synthesize color and specific facial features, 2 components of pain scales that appear to be important for pediatric patients, as mentioned above, and combine these elements into an electronic format. Hence, we propose that universal emojis may help children express not only pain but also other feelings such as nausea, anxiety, disappointment, and confusion, without requiring verbal communication. This innovation could be particularly useful in addressing variations in pain perception and reporting based on factors such as race, ethnicity, and language, since emojis can be adjusted to better match a patient's demographics. An interesting alternative to emojis may be the Bitmoji characters created by Snap Incorporated or the personalized Memoji avatars of Apple Incorporated. These customizable virtual surrogates could further enhance patient engagement and personalization in pediatric pain assessment.

Limitations

Although this updated review lays a foundation for a more targeted approach to pain evaluation in children and adolescents, it has limitations. This review is applicable only to children between the ages of 3 and 18. Additionally, cognitive age was not considered during this evaluation. Future studies should expand upon the findings included above and consider analyzing such parameters and groups.

Notably, this review included both validated acute and chronic pain pediatric studies. Acute and chronic pain have different features and emotional correlates and are experienced in different contexts by children. Therefore, it may be beneficial to assess these components separately in future studies. It must be acknowledged that there may be additional existing or developing pain scales that were not included in our specified search results.

Beyond even these limitations, the included studies also pointed out that the results of individual studies may be altered by the demographic distribution of patient populations. Namely, the observed differences between white and Hispanic patients as well as those between primarily Spanish-speaking and primarily English-speaking patients must be considered when selecting the most clinically appropriate pain scales. Future work to dissect nuanced differences among various populations may allow providers to further refine their selection of pain assessment tools.

Lastly, as with any literature review, we must contemplate how alterations to the present review's selection criteria might have affected the results and conclusions mentioned above.

To summarize these limitations and to be abundantly clear, the present review provides generalizations for children over 3 years of age. Health care providers must recognize the need for an individualized approach to pain assessment and treatment. This review can serve as a starting point; however, it is important to recognize the variety of valid and comparable pain assessment metrics, with the efficacy of these scales ultimately relying on the individual patient.

Conclusions

Pain is a major issue affecting the quality of life of millions of children worldwide. Defining pain for children is more complex than for adults due to children's greater fear and anxiety and less developed communication skills. This systematic review aimed to provide updated information on self-reported pain intensity assessments for children and adolescents. The findings suggest that pain rating scales that use faces and colors have the strongest correlations with other pain scales; however, more research is required to explore the exact influence of fine facial features and the number of faces included in such tools. Since many of the reviewed metrics demonstrate strong correlations, the efficacy and clinical utility of each tool may depend on individual patients, clinical context, and tool familiarity. Generally, the FPS-R or CAS may be more appropriate for acute settings while the NRS-11 or VAS may better describe chronic pain. Similarlly, younger patients may benefit from simplified face-based scales, and additional abstraction as required in the NRS-11 and VAS can be implemented in older populations.

This review also noted that delivering visual pain scales via electronic platforms might improve accuracy and assessment ease for pediatric patients from di-

verse backgrounds. While the incorporation of scales like FACES® into a digital application may be costly, open-source emojis may be a cost-effective solution. Therefore, the pediatric community may benefit from developing a universal, emoji-based, electronic pain scale with the familiar faces and fine features found to be most associated with pain (44,45). Despite the limitations, the findings herein serve as a starting point for future studies to expand and include analysis of other age groups, measures of cognitive age, and considerations of cultural differences. In conclusion, pain assessment should be individualized and tailored to each patient's needs, and health care providers must be aware of the variety of pain assessment tools available to provide effective pain management for children and adolescents.

Author Contributions

JC, AB, TJ, and SH substantially contributed to the conception and design of the study, acquisition of data, analysis of data, interpretation of data, drafting and critical revision of the manuscript, and approval of final version. RE and JB substantially contributed to the analysis of data, interpretation of data, drafting and critical revision of the manuscript, and approval of final version. DL and MM substantially contributed to the acquisition of data by assisting with the literature search, drafting and critical revision of the manuscript, and approval of final version. JC and RE contributed equally to this paper, and they share first authorship of it.

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