Pediatric Regional Examination of the Musculoskeletal System: A Practice- and Consensus-Based Approach

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ORIGINAL ARTICLE

Pediatric Regional Examination of the Musculoskeletal System: A Practice- and Consensus-Based Approach

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Objective. **Competent examination of the pediatric musculoskeletal (MSK) system is a vital component of clinical assessment of children with MSK presentations. The aim was to develop a regional MSK examination for school-age children that is age appropriate and reflects clinical practice.**

Methods. **Qualitative and quantitative analyses involving video observation of clinical examination technique, systematic review, and expert consensus were employed to reveal descriptions, frequencies, and variations in technique for joint regions in various clinical scenarios. Systematic review and data from clinical observation were combined with feedback from a group of pediatric MSK experts through a web-based survey. All results were collated and discussed by consensus development groups to derive the pediatric Regional Examination of the Musculoskeletal System (pREMS).**

Results. **A total of 48 pediatric MSK expert clinicians were involved to derive pREMS. Systematic review revealed a paucity of evidence about regional pediatric MSK examination. Video observations of MSK examinations (a total of 2,901 maneuvers) performed by pediatric MSK experts (n = 11 doctors and 8 therapists) of 89 school-age children attending outpatient clinics in 7 UK pediatric rheumatology centers were followed by semistructured interviews with 14 of 19 clinicians. Video observation showed variation in examination techniques, most frequently at the hip and knee in the context of mechanical and inflammatory clinical scenarios.**

Conclusion. **pREMS is the first practice- and consensus-based regional pediatric MSK examination for school-age children. The structured approach is an important step toward improved pediatric MSK clinical skills relevant to clinical training.**

INTRODUCTION

Children and adolescents commonly present with musculoskeletal (MSK) symptoms with a broad spectrum of causes and in varied guises to family practice or specialties within hospital care (such as pediatrics, orthopedics, rheumatology, and emergency medicine). Appropriate triage and referral are paramount to facilitate optimal outcome and depend on careful clinical assessment. However, low self-confidence in pediatric MSK clinical skills is reported among many doctors to whom children may present (1–4), and performance of MSK examination in pediatric inpatients is poor (5). The reasons for these observations are multifactorial, but it is notable that in the UK, pediatric MSK teaching is not "core" in most medical schools (6). Furthermore, symptoms may not be easily volunteered by young children, history from the parent may not help to localize pathology (7), and pain is a poor discriminator to detect juvenile idiopathic arthritis (JIA) (8). It is therefore likely that poor pediatric MSK clinical skills may contribute to reported delay in referral of children with suspected JIA (9–12), as well as other serious pathology, such as malignancy (13) and muscular dystrophy (14).

Within adult rheumatology clinical teaching in the UK and as part of core clinical teaching (15), medical students are now routinely taught the adult Gait, Arms, Legs and Spine (GALS) MSK screening tool (16) and a Regional

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Significance & Innovations

- A novel approach to deriving regional examination of the musculoskeletal system in school-age children.
- A structured approach to facilitate learning of musculoskeletal clinical assessment in school-age children to be acquired as a minimum skill set by trainees in pediatric rheumatology.

Examination of the Musculoskeletal System (REMS) (17) as a more detailed MSK examination based on the "look, feel, move" approach. There is evidence that the GALS and the REMS are increasingly used in clinical practice and are effective in detecting MSK morbidity among adult inpatients (18–20). However, children are not like adults and in acknowledgment that the GALS missed significant abnormalities in children (21), a pediatric GALS (pGALS) has been developed and validated as an MSK screening examination for the school-age child (21). pGALS has been shown to be acceptable and effective in acute pediatric practice (22) and is taught in many UK medical schools, in institutions beyond the UK, as well as in postgraduate training (e.g., primary care and pediatrics) with teaching facilitated by available free educational resources (URL: www.arthritisresearchuk.org/arthritis_information/information_for_medical_profes.aspx).

As a screening tool, pGALS aims to ascertain whether the child's MSK system is normal or not and whether the clinical assessment needs to be followed by a more detailed joint examination. Therefore, a logical development of pGALS would be a more detailed examination schedule similar to the adult REMS. Clearly, a regional examination needs to address differences in the spectrum of MSK pathology, clinical patterns of joint disease observed in children, and variations in normal development by age, sex, and ethnicity (23).

Our aim was to produce a pediatric REMS (pREMS) of the MSK system that reflects the opinions and expertise of the doctors and physical therapists working in pediatric rheumatology, as well as the spectrum of pediatric MSK clinical practice in pediatric orthopedics. Given that assessment of the younger child will more likely focus on play and function, and may require different approaches, the age range was restricted to school ages (4–17 years). It is envisaged that pREMS will be a logical adjunct to pGALS and analogous to adult MSK clinical skills tools (i.e., GALS and REMS) within clinical teaching. Ultimately, our aim is for pGALS and pREMS to be incorporated into routine clinical practice to facilitate early recognition of MSK disease in children, leading to prompt management and improved outcomes.

SUBJECTS AND METHODS

This study involved 4 phases involving systematic review, video-based observation of clinical examination, expert questionnaire, and consensus group (Figure 1). The study had full ethical approval, and all the participants were assured that their contributions would be confidential with all the transcripts and video material destroyed after study completion.

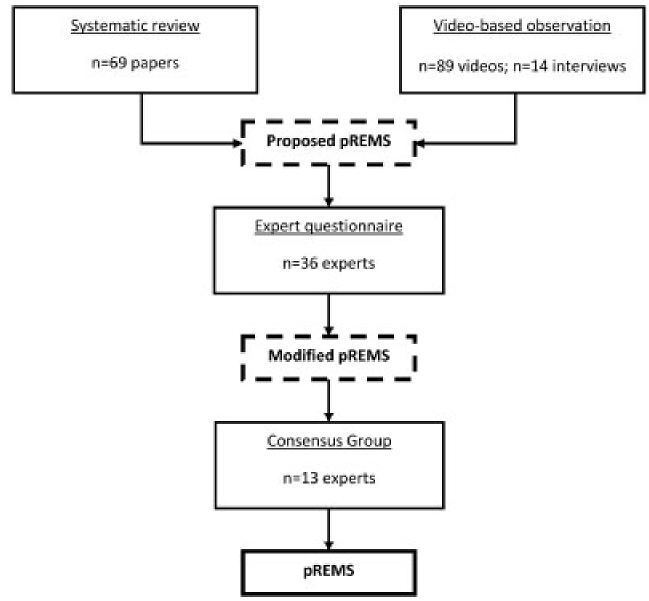

Figure 1. Flow diagram of research phases. pREMS = pediatric Regional Examination of the Musculoskeletal System.

Subjects. All clinicians involved were recruited from centers with pediatric rheumatology clinical services across the UK and are members of the British Society for Paediatric and Adolescent Rheumatology (BSPAR) or the British Society of Children's Orthopaedic Surgeons (BSCOS). Participants were recruited by e-mail or telephone invitation. To obtain a range of opinions, different groups of clinicians were invited to take part in the video observation and expert questionnaire phases; the consensus group included all clinicians who had taken part in the video observation phase as well as other clinicians who had not. Over all phases of the study, 48 different UK pediatric MSK practitioners (mostly doctors) who were deemed "experts" in the study were involved (15 pediatric rheumatologists, 11 adult rheumatologists with an interest [and postgraduate training] in pediatric rheumatology, and 6 pediatricians with an interest [and postgraduate training] in pediatric rheumatology). In addition, 8 physiotherapists (6 in pediatric rheumatology and 2 in pediatric orthopedics), 2 consultant pediatric orthopedic surgeons, and 5 others: 2 trainees who had completed subspecialist training (Higher Specialist Training [HST]) in pediatric rheumatology in the UK, 2 pediatric occupational therapists, and 1 clinical nurse specialist trained in clinical examination. School-age children and adolescents (ages 4–17 years) were recruited from outpatient clinics (in both pediatric rheumatology and pediatric orthopedics), and exclusion criteria included children with neurologic disease, severe learning disabilities, or deemed by the doctor to be too unwell to take part.

Systematic review. We conducted a systematic narrative literature review of the published pediatric MSK examination techniques for each joint, normal ranges of movement in school-age children, and gait, including eponymous tests (e.g., Trendelenburg's test), and using Medline (January 1966 through April 2006) and CINHAL (1982 through May 2006). The search combined a text word search for "musculoskeletal" with medical subject headings (MeSH) of "exp musculoskeletal diseases," "exp joints," "exp movement disorders," "movement," "gait," "head movements," and "locomotion" linked by OR terms. This search was combined with relevant terms including "pediatrics," "child," "adolescent," "physical examination," "diagnosis," "screening," "standards," "education, medical," "rheumatology," "orthopedics," "physiotherapy," "physical therapy," and "occupational therapy." We also searched 2 other databases, PEDro and OTSeeker. We hand-searched the literature, including standard reference textbooks, and consulted domain experts. Only the articles available in English were included. The Medline search was repeated in August 2008 and October 2010 to capture additional publications.

Video-based observation. To gain an objective record of the range of clinical skills performed in current expert clinical practice, clinicians (doctors and therapists) working in 7 pediatric rheumatology centers were recruited along with their local colleagues in pediatric orthopedics where possible. Each center was visited by a nonclinical researcher (TR) and, once appropriate consent was obtained (clinician, parent/caregiver consent, and where appropriate, patient's assent), outpatient clinic consultations with school-age children and adolescents were video-recorded. After the recording phase was complete, clinicians were asked to select 2 consultations (of their choice) to review and discuss: 1 routine and 1 noteworthy (e.g., demonstrating a physical sign) or atypical (e.g., use of an additional maneuver to confirm or refute a physical sign). During a semistructured interview between the nonclinical researcher and the expert, the recordings were played back, and the experts were asked to account for the verbal and nonverbal components of their examination, explaining specific clinical skills in that clinical context and their interpretation of the meaning (24). With appropriate consent, interviews were audio-recorded and transcribed.

Qualitative analysis (25) was undertaken on the video-recordings and interviews in order to identify, list, and describe the range of maneuvers for each region, as well as to describe the clinical reasoning behind them. A coding frame was developed. Quantitative content analysis (26) was undertaken, supported by Observer software, version 4.1 (Noldus Technology Information), in order to identify and describe the specific maneuvers in each examination. One researcher (TR) coded the entire data set. Inter- and intrarater reliability testing of the video coding involved 2 other researchers, who independently coded 5 randomly selected videos, and the original researcher (TR) re-coded 5 videos.

Expert questionnaire. Results from the systematic review and video observation were used to inform the content of a web-based questionnaire using SurveyMonkey. Think-aloud interviews (27) were used to pretest the questionnaire for understanding and content validity with 5 clinicians (doctors and therapists) recruited from BSPAR and BSCOS. For each joint or anatomic region, specific maneuvers were listed in order of look, feel, and move, and "further clinical assessment pending clinical scenario," with respondents asked to comment if the maneuver should be included in pREMS or not (possible responses were yes, no, not sure, or no opinion). Participants were requested to make a judgment based on pREMS being the core level of expertise to be acquired by the subspecialist trainee in pediatric rheumatology at the time of completion of their postgraduate training when they are eligible to be appointed as consultants in pediatric rheumatology. Free-text comments were invited, and 1 reminder was sent to all nonresponders after 2 weeks.

Consensus group. We aimed to reach agreement on the core components of pREMS appropriate to completion of clinical training in pediatric rheumatology. Findings from the prior phases of the project were collated into a booklet for discussion by the consensus group (all were pediatric MSK experts from across the UK and many, but not all, had taken part in one of the previous phases of the project). The booklet (circulated prior to the meeting) contained a list of maneuvers (in order of look, feel, move) for each joint or anatomic region, with an accompanying photograph to aid understanding, the number of times each maneuver was observed on the videos, any pertinent data from the literature, and results of the web-based survey. Maneuvers that had been excluded (defined as >80% agreement for the maneuver not to be included in pREMS) were also available following the survey as were all free-text comments. At the consensus meeting, maneuvers for each joint or anatomic region were discussed and consensus reached through voting if there was <80% agreement achieved through the expert questionnaire. The discussion was audio-taped and transcribed to facilitate accurate production of a revised version of pREMS; this was circulated after the meeting to all participants with comments invited and collated to produce a final version of pREMS.

RESULTS

Literature review. The literature search identified 1,757 references that evaluated or described MSK examination techniques used that were applicable to school-age children (Figure 2); the vast majority of them, however, were descriptions or simply lists of techniques without evidence for their use in clinical practice. A total of 69 (3.9%) of 1,757 references fulfilled the search criteria for appraisal; the majority described techniques by region (spine and scoliosis evaluation [n = 23], knee [n = 10], hip [n = 6], and foot and ankle [n = 4]) and were mostly descriptions of maneuvers used for noninflammatory conditions and often related to sports medicine (e.g., mechanical stability at the knee). A screening examination was described in 15 of the 69 references and included pGALS and tests for scoliosis. No validated, consensus-, or evidence-based regional pediatric MSK examinations were described.

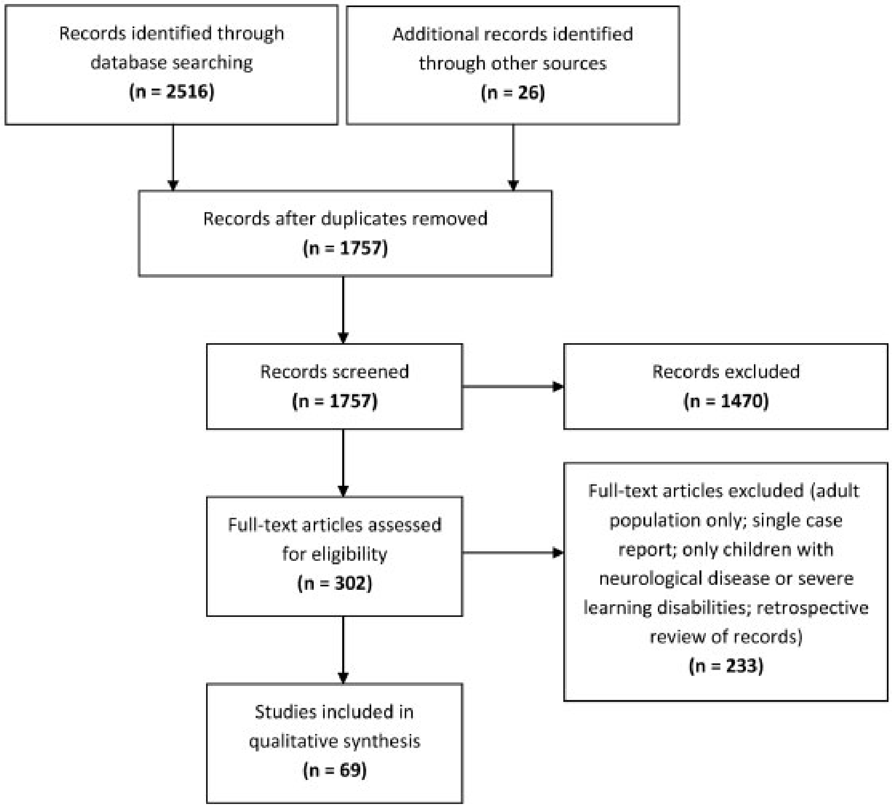

Figure 2. Flow diagram of narrative systematic review.

Observations by video. Video observations were undertaken in 7 centers, 5 of which (Glasgow, Newcastle, London, Liverpool, and Bristol) are accredited for UK pediatric rheumatology subspecialty training (termed HST in the UK). Two more centers with a dedicated pediatric MSK service (Portsmouth and Oxford) were recruited. A total of 89 outpatient consultations performed by 19 clinicians were video-recorded, followed by one-on-one interviews with 14 of 19 clinicians who consented for the interviews to be recorded. Most participants in this phase were doctors working in pediatric rheumatology (Table 1), and 54 patients had a diagnosis of JIA (including oligoarticular [31%, n = 17], polyarticular [27%, n = 15], systemic [9%, n = 5], and JIA with other/not defined [16%, n = 9]) (Table 2). There was an additional 26 children with noninflammatory or mechanical problems, mainly in the lower extremity (38%, n = 10), including normal variants (such as flat fleet, intoeing) and hypermobility (50%, n = 13). Three patients had yet to receive a final diagnosis, and an additional 6 patients had "other" inflammatory diagnoses (including chronic recurrent multifocal osteomyelitis). There were no patient or health care professional withdrawals from the study.

Qualitative analysis of videos and stimulated interviews (24) identified more than 480 different examination maneuvers, which were then aggregated to 294 specific codes (final version of the coding frame available on request) or divided into look-, feel-, and move-based actions for each joint or anatomic region. It was also determined whether the maneuver was performed by a passive or active movement, as well as the positioning of the patient (e.g., lying on couch, prone, or supine). We also recorded independent variables (e.g., patient age, practitioner specialty). The coding frame was applied to all 89 patient examinations with reliability of data coding established by inter- and intrarater reliability statistics (Fleiss' kappa, Cohen's kappa, and Krippendorff's alpha). The overall average in-

Table 1. Specialty of practitioners participating in the videotaped observation of MSK examinations*

Pediatric practitioner specialty	No.	Video-recorded examinations†
Rheumatologist	8	52 (58)‡
Orthopedic surgeon	1	8 (9)
Physiotherapist§	6	21 (23.6)
Nurse specialist (pediatric rheumatology)	1	6 (6.7)
HST (pediatric rheumatology)	2	2 (2.2)
Occupational therapist	2	¶
Total	20	~89 (100)

* Values are the number (percentage) unless indicated otherwise. MSK = musculoskeletal; HST = higher specialist trainee.
† Denotes the number of examinations led by the practitioner listed.
‡ The total of 52 includes 18 examinations led by the doctor with input from a physiotherapist (n = 16) or an occupational therapist (n = 2).
§ Physiotherapist in rheumatology (n = 5), orthopedics (n = 1).
¶ Two consultations involved some input from an occupational therapist and are included in the doctor-led examinations.

Table 2. Demographic and clinical characteristics of school-age patients recruited to video-based observation phase

	Patients, no. (%) (n = 89)
Age, years	
4–6	21 (24)
7–10	22 (25)
11–14	26 (29)
14–17	16 (18)
Others ages 4–17 years, exact age not given	4 (4)
Female	58 (61)
Male	31 (39)
Primary diagnosis	
Inflammatory	54 (61)
Noninflammatory	26 (29)
Other	6 (7)
No diagnosis recorded	3 (3)
Status	
New patient	79 (89)
Review patient	10 (11)

terrater reliability was excellent at 0.823 with the intrarater reliability at 0.849.

A total of 2,901 maneuvers at all joints were observed (Table 3). There was considerable variation in the assessment technique used to examine each region both in terms of the number of maneuvers used (Table 3) and the technique used (e.g., different methods to assess for effusion at the knee including patella tap, cross fluctuation, or ballottement). Notably, saturation was observed, i.e., by the end of the study, there was recurrence of the techniques used in practice and within centers, and similar examination approaches and routines were observed between different clinicians working in that center (e.g., examining the hands first or the feet first). A median of 33 different maneuvers were observed per child being examined (range 0–68), a median of 4 per joint (range 0–21, with most variance being observed at the foot and ankle [26.9], followed by the hand and wrist [21], spine [14.2], and the least at the elbow [3.8]).

Questionnaire responses. The findings of the review and observational phases were combined, and the resulting proposed regional MSK examination was evaluated through a web-based survey. Responses were received from 36 (69%) of 52 invitees recruited from BSPAR and BSCOS, with participants from pediatric rheumatology, pediatric orthopedics, and both doctors and therapists. Respondents were asked to evaluate 123 maneuvers (related to specific anatomic regions [n = 108] and related to clinical contexts [n = 15, e.g., hypermobility, suspected connective tissue disease]). The majority of respondents (72%, 26 of 36) voted for 116 (of 123) maneuvers to be included as core for HST in pediatric rheumatology. Notably, disagreement arose regarding some maneuvers being core for HST in pediatric orthopedics rather than pediatric rheumatology. For example, assessment of foot-thigh angle in the child with suspected intoeing had the highest level of uncertainty, with 14% (5 of 36) stating "no opinion" and 14% (5 of 36) stating "not required." However, for the trainee in pediatric orthopedics, this would be regarded as a core clinical skill.

Consensus on components of pREMS. The group included a total of 13 clinicians: pediatric rheumatology (n = 4 consultants, n = 3 physiotherapists), pediatric orthopedics (n = 1 consultant, n = 1 physiotherapist), pediatricians with an interest in rheumatology (n = 3), and 1 rheumatologist with an interest in clinical skills education. Participants focused on one region at a time, discussing each maneuver and whether it should be acquired at completion of pediatric rheumatology clinical training. Where necessary, voting was conducted with a threshold of >80% agreement used to reach consensus. The final version of pREMS (Supplementary Appendix 1, available in the online version of this article at http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)2151-4658) includes the core skills for HST pediatric rheumatology. The majority of skills were also deemed likely to be essential for HST in pediatric orthopedics and pediatric physiotherapy. Certain skills, such as Patrick's test or Faber's test for sacroiliac irritation or measuring thigh-foot angle, were deemed important for trainees in pediatric rheumatology to be

Table 3. Frequency of examination maneuver by region

	Maneuvers per examination				
Region	Range	Median	SD	Variance	Total maneuvers per region, no.
Hand/wrist	0–16	7	4.583	21.002	581
Elbow	0–8	2	1.958	3.832	213
Shoulder	0–13	3	2.195	4.818	218
Hip	0–10	3	2.038	4.154	261
Knee	0–10	5	2.393	5.728	405
Foot/ankle	0–21	8	5.185	26.889	757
Spine	0–18	5	3.775	14.247	428
Other*	0–3	0	0.655	0.429	36
Total	0–68	33	13.96	194.97	2,901

* Maneuver codes pending clinical scenario, e.g., "check elasticity of skin" in the child with hypermobility and "check for rash" in the child with inflammatory arthritis.

aware of, but not necessarily competent in the performance thereof.

DISCUSSION

This is the first consensus-derived approach to regional MSK examination for the school-age child. We have called this pREMS to complement the existing adult REMS (17) and a similar structured approach based on look, feel, and move.

It is noteworthy that REMS was derived from consensus opinion on the use and value of standardized and published descriptions of clinical examination techniques in adults. This methodology was not possible to derive pREMS, since our literature search corroborated previous reviews (28,29) and revealed a paucity of evidence-based literature. For pREMS it was therefore important to first identify, describe, and understand existing expert pediatric MSK clinical practice as it is routinely undertaken as a baseline before deriving consensus. The video observation of pediatric MSK clinical practice was important to distinguish between "textbook knowledge" (i.e., the normative recommendations of experts) as revealed by existing clinical literature and systematic review, and "real-time practice" (i.e., what experienced clinicians actually do in practice and what the findings reveal to them).

Consensus methodology was used in both the derivation of REMS and pREMS and involved a range of stakeholders working in pediatric MSK medicine. The numbers of available clinicians involved in the derivation of pREMS are smaller than those used to derive REMS, largely reflecting the difference in methodology and the clinical community in the UK; nonetheless, the number involved reflects a significant proportion of pediatric rheumatologists in the UK (currently tertiary specialists, n = 23). For pREMS, it was clearly important to involve stakeholders from rheumatology and orthopedics, both doctors and therapists, and representatives from across the UK to ensure a spectrum of opinion from expert clinicians. However, we realize that we have generated a spectrum of opinion from UK expert clinicians only, and an international study may have revealed more diversity. The inclusion of experienced pediatric MSK therapists was important since they are integral to clinical practice as an invaluable adjunct to medical assessment; their clinical skills are therefore likely to inform pREMS as core clinical skills relevant to HST in pediatric rheumatology.

In the UK, mandatory professional medical examinations for pediatrics are completed before entering subspecialist HST in pediatric rheumatology. This differs from training elsewhere, where examinations are taken at the end of subspecialist training. In recent years, the UK training pediatric subspeciality HST program has changed toward competency based training (http://www.rcpch.ac.uk/training-examinations); we envisage that pREMS will be an important step toward standardization of postgraduate medical training.

We believe that the study was representative of current clinical practice within pediatric MSK medicine with video observations covering a spectrum of outpatient clinics (new and review), children of different ages attending rheumatology and orthopedic clinics across different UK centers, and involvement of different stakeholders. The observational fieldwork was undertaken by a nonclinical researcher (TR) to avoid bias (through prejudice or preconceptions) and to be perceived as less threatening to the experts (30). Participation was optimized by assurance that all contributions from participants would be anonymized and erased after transcription and analysis. We acknowledge recruitment bias toward clinicians working in pediatric rheumatology despite considerable efforts to engage with all stakeholders; consequently, there is bias toward there being more inflammatory diagnoses rather than mechanical or soft tissue problems. The bias toward rheumatology was the main reason for defining pREMS as core for HST in pediatric rheumatology, although many components of pREMS are clearly relevant for trainees in other aspects of pediatric MSK medicine, such as orthopedics or sports medicine.

The final version of pREMS includes maneuvers for each anatomic region or joint (Supplementary Appendix 1, available in the online version of this article at http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)2151-4658) using the look, feel, and move approach used in adult REMS but with the addition of "measure" to allow for clinical contexts deemed to be commonly relevant to pediatric practice (e.g., leg length or muscle power strength). Interpretation of pREMS clearly requires knowledge of normal MSK development (i.e., gait, leg alignment, normal variants) and ranges of joint movement according to age, sex, and ethnicity (23). The main differences between pREMS and adult REMS are at the hip, foot, and ankle (Supplementary Appendix 1, available in the online version of this article at http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)2151-4658) and likely reflect differences in important pathologies at these sites across the age range. Where there was variation in performance of some components of pREMS, consensus on technique was largely based on our observation of current clinical practice. For example, there were several ways observed to assess for effusion at the knee and, in the absence of data about validity of specific maneuvers, this clearly requires further work. Although many maneuvers were frequently used in clinical practice (e.g., passive full flexion and internal and external rotation of the hip [78%, n = 69 of 89 maneuvers]), some were much less commonly observed. Even in the presence of inflammatory conditions (e.g., squeezing metacarpophalangeal [MCP] joints was infrequently observed [6.7%, n = 6 of 89 maneuvers]), this may reflect a difference in the pattern of inflammatory joint involvement in children or a reluctance to induce pain in a child with other evidence of joint disease in the hand. Nonetheless, strong opinion to include squeezing MCP joints in pREMS emphasizes it as an important clinical skill, and it is more likely to be performed in control patients where the diagnosis is not clear. Notably, pREMS does not specify the order in which joints or regions should be examined; this is important to address in teaching and acknowledges that clinical examination is directed by the clinical context and that clinicians develop their own routine.

The consensus was that pREMS is a postgraduate "core" clinical skill set aimed at the HST in pediatric rheumatology, although there is likely to be considerable overlap with other trainee fields such as pediatric orthopedics, sports medicine, and pediatric physiotherapy. The level of competence required for each maneuver was deemed variable pending the specialist area, e.g., competent performance of foot-thigh angle assessment was not deemed mandatory for pediatric rheumatology trainees, but such trainees need to be aware of its use in the assessment of the child with intoeing. It was judged that medical students at the time of qualification from medical school need to be aware of pREMS, but that competence in the whole range of pREMS would be acquired as a postgraduate skill. pREMS is deemed the minimum for HST in pediatric rheumatology and does not preclude additional clinical maneuvers being used in clinical practice by experts in the field.

The purpose of pREMS is to provide a structured approach to the MSK assessment of the school-age child and is a logical development from pGALS as a screening routine. It is hoped that the structured approach of pREMS will facilitate teaching and learning and be an important adjunct to a "tool-kit" of adult MSK and pediatric MSK clinical skills as part of clinical training. Ultimately, we hope that improved pediatric MSK clinical skills will facilitate early recognition of significant rheumatic disease in children and appropriate referral to specialist services.

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AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be submitted for publication. Dr. Foster had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study conception and design. Foster, Kay, May, Rapley.

Acquisition of data. Foster, Rapley.

Analysis and interpretation of data. Foster, Kay, May, Rapley.

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