Musculoskeletal Screening Examination (pGALS) for School-Age Children Based on the Adult GALS Screen

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Objective. To develop and validate a musculoskeletal screening examination applicable to school-age children based on the adult Gait, Arms, Legs, Spine (GALS) screen.

Methods. Adult GALS was tested in consecutive school-age children attending pediatric rheumatology clinics and was compared with an examination conducted, on the same day, by a pediatric rheumatologist who classified children as having abnormal or normal joints. Adult GALS was tested for validity compared with the pediatric rheumatologist’s assessment and deficiencies in adult GALS were identified. Experts proposed amendments to adult GALS, achieving consensus by modified Delphi techniques. The resultant pediatric screening tool (pGALS) was tested (methodology identical to the testing of adult GALS) in an additional group of children.

Results. Adult GALS was tested in 50 children (median age 11 years, range 4 –16), of whom 37 (74%) had juvenile idiopathic arthritis. Adult GALS missed important abnormalities in 18% of children, mostly at the ankle, foot, and temporomandibular joints. The pGALS was tested in 65 children (median age 13 years, range 5–17 years) and demonstrated excellent sensitivity (97–100%) and specificity (98–100%) at all joints, with high acceptability scored by child and parent/guardian. The median time to perform pGALS was 2 minutes (range 1.5–3 minutes).

Conclusion. The pGALS musculoskeletal screening tool has excellent validity, is quick to perform, and is acceptable to school-age children and parents/guardians. We propose that pGALS be incorporated into undergraduate and postgraduate medical training to improve pediatric musculoskeletal clinical skills and facilitate diagnosis and referral to specialists.

KEY WORDS. Musculoskeletal; Children; Pediatric; Screening examination; Clinical skills; GALS; Medical education; pGALS; Juvenile arthritis; Barriers to care.

INTRODUCTION

Musculoskeletal symptoms in children and adolescents are very common, occurring in 4–30% of young persons (1–3) and accounting for 3% of day case attendances (4).

The differential diagnosis is broad, and although in many cases the cause is self-limiting, musculoskeletal presentations are not uncommon in severe, even life-threatening illnesses such as osteomyelitis, leukemia, juvenile idiopathic arthritis (JIA), vasculitis, or nonaccidental injury. Careful performance of a competent musculoskeletal examination is vital to the diagnostic process, particularly because musculoskeletal symptoms are not always easily volunteered by children, parental observations may be nonspecific (e.g., “my child is limping”), and joint swelling and abnormal gait (such as limp) rather than reported pain are the most common presenting features of JIA (5,6).

JIA is a common cause of chronic disability in children (7), and joint damage occurs early (8,9). Emerging evidence supports early and aggressive intervention to improve functional outcome (10–13), which relies on prompt diagnosis and referral to experienced multidisciplinary teams (7,9,14). However, for many children with suspected JIA, delay in receiving pediatric rheumatology services is not uncommon (6,15), with complex referral pathways from...
their primary care doctor to different secondary care services (primarily general pediatrics, orthopedics, and accident and emergency).

Poor clinical skills are a significant barrier to care, with trainees in pediatrics and primary care reporting poor self-confidence in their ability to assess a child’s musculoskeletal system (4,16–19), poor documentation of musculoskeletal assessment (16), and inadequate training in pediatric rheumatology (4,20,21). These observations may be explained by the fact that teaching of musculoskeletal clinical skills involving children is not part of core training in UK medical schools (22), few standard pediatric textbooks describe musculoskeletal clinical examination techniques in children (23), and clinical skills are not reinforced in clinical practice because pediatricians themselves may not have received appropriate training. Furthermore, there is no consensus among pediatric rheumatologists as to best practice in musculoskeletal clinical examination, and there is no validated screening examination applicable to children (24).

Poor musculoskeletal clinical skills are not unique to pediatric practice, and musculoskeletal system is often omitted from routine medical adult patient assessment (25). Following the General Medical Council (UK) recommendations that musculoskeletal clinical conditions be emphasized in undergraduate teaching (26), musculoskeletal examination is taught in UK medical schools as part of core teaching (22), and many students are taught the Gait, Arms, Legs, and Spine (GALS) screening examination and are introduced to the basic elements of a more detailed regional examination (27). The GALS involves simple questions and procedures that permit rapid and effective assessment of the musculoskeletal system in adults (28,29), but it has not been tested in children.

An ideal musculoskeletal screening test for children must be sensitive (i.e., does not miss significant abnormalities), be acceptable to the child and parent, distinguish the abnormal child from the normal child, and direct the assessor to a focused regional examination. Our goal was to produce a validated pediatric musculoskeletal screening test based on adult GALS that can be successfully integrated into clinical teaching and will improve pediatric musculoskeletal clinical skills among future doctors. Ultimately, the goal is that improved pediatric musculoskeletal clinical skills will facilitate diagnosis and, in the case of children with suspected rheumatic disease, reduce the delay to pediatric rheumatology care and therefore optimize outcome. The study was limited to school-age children because a different examination approach would be required for younger children.

PATIENTS AND METHODS

Part 1 tested adult GALS in school-age children in comparison with a consultant pediatric rheumatologist’s assessment. Part 2 derived amendments to adult GALS from expert opinion. Part 3 tested the amended version of adult GALS.

Part 1: Audit of adult GALS applied in school-age children. Children were recruited from pediatric rheumatology outpatient clinics, with both new and review patients invited to participate. Participants were examined using adult GALS by a final-year specialist registrar (AM) in adult rheumatology experienced in the use of adult GALS who was blinded to the diagnosis, with no clinical history being permitted other than the 3 screening questions (i.e., “Do you have any pain in your joints, muscles, neck or back?” “Do you have any difficulty getting dressed without help?” and “Do you have any difficulty getting up and down stairs without help?”). On the same day, children were examined by a consultant pediatric rheumatologist (HF or MF); this process mirrors clinical practice, with patients being assessed by the specialist registrar and subsequently by the consultant. The time to perform the examination and findings were recorded on a homunculus. The consultants, blinded to the specialist registrar’s findings, used their standard clinical approach, and were asked to record joints as normal or abnormal and also to document a more detailed description of abnormalities. To assess interobserver variation, the first 10 patients were assessed independently by both consultants and the interobserver reproducibility (to distinguish abnormal from normal joints) was satisfactory, with an intraclass correlation coefficient of 0.81 (>0.8 is regarded as satisfactory [30,31]). The sensitivity, specificity, and positive and negative predictive values of the adult GALS screen were calculated from comparison with the consultant examination.

Part 2: Derivation of amended version of adult GALS. The amendments required for adult GALS were derived through consultation with members (doctors and allied health professionals) of the British Society for Pediatric and Adolescent Rheumatology (BSPAR), with invitations to participate being distributed at BSPAR national meetings. The respondents (termed experts) were involved in subsequent dialogue to reach consensus. The proposed amendments were derived through a modified Delphi technique (32) that involved 2 iterative cycles, with questionnaires incorporating feedback from discussion groups of experts. Survey 1 followed presentation, at a national BSPAR meeting, of the results of adult GALS testing in children (33). Experts were asked by questionnaire to judge whether, in their opinion, each of the components of adult GALS was essential, desirable, or not necessary. They were also asked to suggest amendments for joints where adult GALS performed less well. A subsequent questionnaire (survey 2) asked the experts to judge whether, in their opinion, each of the proposed amendments to adult GALS was essential, desirable, or not necessary. The results were then discussed in an expert group to derive consensus.

Part 3: Testing of pGALS in school-age children. The proposed amended version of adult GALS was termed pediatric GALS (pGALS), which was tested, using methodology identical to the testing of adult GALS, on an additional group of consecutive outpatient attendees. A power calculation (80% power, $P = 0.05$) required 60
children to test the amendments to adult GALS, including 96 normal joints and 24 abnormal joints at each anatomic site. Acceptability of pGALS according to the child and parent/guardian was recorded on a Likert scale (range 0–5) for their opinion on 1) the time taken to perform pGALS, with a scale of 5 options (ranging from “far too short” to “far too long”), and 2) the level of discomfort experienced during the examination, with a scale of 5 options (ranging from “lots of pain” to “no pain”).

The study had ethical approval, with informed consent obtained from parents/guardians and assent obtained from older children. All information was recorded anonymously.

RESULTS

Patients used to test adult GALS and pGALS. Adult GALS was tested in 50 consecutive school-age children (25 girls, median age 11 years [range 4–16 years]). Of these, 42 had inflammatory joint disease (37 had JIA, 2 had systemic lupus erythematosus, 2 had reactive arthritis, and 1 had juvenile dermatomyositis) and 8 had noninflammatory joint disease (5 had benign joint hypermobility and 3 had anterior knee pain). The testing of pGALS involved 65 children (42 girls, median age 13 years [range 5–17 years]) with the following diagnoses: inflammatory joint disease (40 had JIA, 1 had systemic lupus erythematosus, 5 had juvenile dermatomyositis, and 3 had systemic sclerosis), mechanical joint problems (8 had benign joint hypermobility and 5 had anterior knee pain), primary Raynaud’s disease (2 patients), and idiopathic pain syndrome (1 patient).

The expert group to derive amendments to adult GALS. From the membership of BSPAR (n = 124), 36 members (representing 20 pediatric rheumatology units within the UK) agreed to participate, with larger centers nominating 1 representative consultant. All experts responded to the surveys and most (32 of 36) attended a minimum of 1 discussion group. The expert group included 25 pediatric rheumatologists, 6 of whom were trainees; 6 physiotherapists; 1 occupational therapist; 3 clinical nurse specialists; and 1 pediatric orthopedic surgeon.

Testing of adult GALS in school-age children (part 1). The median time for the specialist registrar to perform adult GALS was 2 minutes (range 1–2.5 minutes). Adult GALS had good sensitivity and specificity for the joints that are included in the screen, and the negative predictive values at each of these sites were high, suggesting that the adult GALS screen did not miss significant abnormalities in the areas examined (Table 1). However, adult GALS rated 19 of 50 children as normal, but the pediatric rheumatologist’s examination detected abnormalities in 9 of these 19 children (5 had JIA and 4 had benign hypermobility); adult GALS therefore had a false negative rate of 18% (9 out of 50). A total of 55 joint abnormalities were missed by adult GALS, the majority of which involved the foot and ankle (namely, restricted range of movement of ankle joint [n = 20], subtalar joint/midfoot [n = 13], tenosynovitis/tendinitis [n = 6], arthritis of an individual toe [n = 4], and abnormal foot posture [n = 8]). Four patients with JIA had temporomandibular joint (TMJ) abnormalities that were missed, which included limited jaw opening/deviation. The positive predictive value of adult GALS was low at the wrist, elbows, and neck (30%, 55%, and 66%, respectively), with loss of range of movement being the main abnormality missed. Significant amendments to adult GALS were therefore needed to incorporate the foot, ankle, and TMJ, and improvement in the specificity of the adult GALS screen at the wrist, elbow, and neck was needed.

Development of pGALS by expert opinion (part 2). Survey 1 suggested amendments for the foot and ankle, and following survey 2, there was consensus for “walk on tip toes and then heels” (as desirable or essential) as the screening test (Figure 1). In survey 1, the suggested amendments for the TMJ were “open jaw” and “move jaw side to side.” Following survey 2, there was consensus to refine this as “open (your) mouth and insert 3 fingers” (child’s own fingers) as the screening test for the TMJ. Most com-
Components of adult GALS were scored as desirable or essential (survey 1), with consensus to keep the format of pGALS as similar to adult GALS as possible, except for “put your arms by your side” being replaced by “reach for the sky” as a more effective screening test for elbow extension. Another proposed amendment for the wrists was “palms together and hands together back to back,” and a proposed amendment for the neck was “look at the ceiling.”

The pGALS maneuvers are listed in Table 2 and illustrated in Figure 2. The TMJ screening test is the observation of facial profile (looking for asymmetry of movement or deviation) using the child’s own 3 fingers to gauge the degree of opening. Inability to walk on the heels may be a feature of tendinitis, enthesitis or arthritis of the ankle/foot, and osteochondroses (e.g., Sever’s disease). Toe walking alerts the observer to possible neuromuscular disease but has been reported as a presenting feature of JIA (34). Inability to walk on the toes may be a feature of arthritis (metatarsalgia) or local trauma of the foot. The appearance of flat feet but normal arches on tip-toe is normal in young children until ~5 years of age. Persistence of flat feet beyond this age or a nonmobile flat foot warrants further investigation. In the school-age child with mechanical lower limb pain (e.g., anterior knee pain), abnormal foot posture (including flat feet, excessive pronation/supination of the feet) may be found.

Testing of pGALS for validity and acceptability (part 3). The pGALS screen had excellent sensitivity and specificity at all joints (Table 3). There were no false negatives; pGALS did not miss any children with significant joint

Table 2. The components of pediatric Gait, Arms, Legs, Spine screen (pGALS)*

<table>
<thead>
<tr>
<th>Screening questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you have any pain or stiffness in your joints, muscles or your back?</td>
</tr>
<tr>
<td>Do you have any difficulty getting yourself dressed without any help?</td>
</tr>
<tr>
<td>Do you have any difficulty going up and down stairs?</td>
</tr>
<tr>
<td>Gait</td>
</tr>
<tr>
<td>Observe the child walking</td>
</tr>
<tr>
<td>“Walk on your tip-toes/walk on your heels” (A,B)†</td>
</tr>
<tr>
<td>Arms</td>
</tr>
<tr>
<td>“Put your hands out in front of you” (C)</td>
</tr>
<tr>
<td>“Turn your hands over and make a fist” (D)</td>
</tr>
<tr>
<td>“Pinch your index finger and thumb together”</td>
</tr>
<tr>
<td>“Touch the tips of your fingers with your thumb” (E)</td>
</tr>
<tr>
<td>Squeeze metacarpophalangeal joints (F)</td>
</tr>
<tr>
<td>“Put your hands together/put your hands back to back” (G,H)†</td>
</tr>
<tr>
<td>“Reach up and touch the sky” (I)†</td>
</tr>
<tr>
<td>“Look at the ceiling” (L)</td>
</tr>
<tr>
<td>“Put your hands behind your neck” (J)</td>
</tr>
<tr>
<td>Legs</td>
</tr>
<tr>
<td>Feel for effusion at the knee (K)</td>
</tr>
<tr>
<td>“Bend and then straighten your knee” (active movement of knees and examiner feels for crepitus) (L)</td>
</tr>
<tr>
<td>Passive flexion (90 degrees) with internal rotation of hip (M)</td>
</tr>
<tr>
<td>Spine</td>
</tr>
<tr>
<td>“Open your mouth and put 3 of your (child’s own) fingers in your mouth” (N)†</td>
</tr>
<tr>
<td>Lateral flexion of cervical spine: “try and touch your shoulder with your ear” (O)</td>
</tr>
<tr>
<td>Observe spine from behind (P)</td>
</tr>
<tr>
<td>“Can you bend and touch your toes?” observe curve of spine from side and behind (Q)</td>
</tr>
</tbody>
</table>

* See Figure 2 for illustrations of individual movements (A–Q).
† Additions and amendments to the original adult Gait, Arms, Legs, Spine screen.
abnormalities that were detected by the pediatric rheumatologist examination. A positive response to ≥1 of the 3 screening questions (i.e., “there was pain and/or stiffness,” “difficulty in dressing independently,” or “difficulty with stairs”) gave the following results as compared with the consultant’s assessment: sensitivity 49%, specificity 82%, positive predictive value 85%, and negative predictive value 37%. The median time to complete pGALS was 2 minutes (range 1.5–3 minutes). The acceptability questionnaires were completed by 49 of 65 children (the nonresponders being very young children) and by 45 of 65 parents/guardians (the nonresponders not having witnessed the examination performed on older children/young persons who opted to be examined by the doctor on
and cause significant morbidity (40). Often involved in children with JIA, may be subclinical, TMJs need to be specifically screened because they are particularly because the observer must be aware of the abnormalities (such as restriction of the subtalar joints), not be relied upon to detect significant foot and ankle abnormalities (such as restriction of the subtalar joints), and the gait and normal variants in children (39). The development of gait and normal variants in children (39).

**DISCUSSION**

This is the first description of a validated musculoskeletal screening test for school-age children. The pGALS test performs very well; it is sensitive, quick to perform, and is acceptable to children and parents/guardians. The pGALS screen was derived from adult GALS, which has been used as part of core teaching in UK medical schools since 1991, is widely accepted by teachers in rheumatology, and effectively improves musculoskeletal clinical competence among junior doctors assessing adults (25,35,36). It is envisioned that pGALS, being similar to adult GALS in format and content, will be equally effective in the improvement of clinical competence in the musculoskeletal assessment of children. We believe that competent pediatric musculoskeletal clinical skills will facilitate accurate diagnosis, referral to specialist teams, and, most importantly for children with suspected rheumatic disease, reduce delay in referral to pediatric rheumatology care and ultimately improve these children’s outcome.

Adult GALS is not adequate, in its original form, as a musculoskeletal screening tool for use in school-age children. The majority of the abnormalities that were missed were at the foot and ankle and the TMJ, which are not specifically tested in the original description of adult GALS (28). These sites are commonly involved in JIA, especially at presentation (6,37,38). Gait observation cannot be relied upon to detect significant foot and ankle abnormalities (such as restriction of the subtalar joints), particularly because the observer must be aware of the development of gait and normal variants in children (39). TMJs need to be specifically screened because they are often involved in children with JIA, may be subclinical, and cause significant morbidity (40).

The pGALS screen had excellent sensitivity and specificity compared with the consultant assessment, which is all the more impressive given the lack of detailed clinical history included in the screen. The screening questions, however, have low sensitivity (but high specificity and high positive predictive value), demonstrating that clinical history alone may be unhelpful as a musculoskeletal screening tool. Nonetheless, these questions are helpful prompts to the history taker and help focus the examiner’s attention if a positive response is obtained.

The methodology to propose amendments to adult GALS (based on the Delphi process [32]) has been used effectively in health care research, development of guidelines for best practice and content of curricula (41), and in pediatric rheumatology (42). There is no published consensus on musculoskeletal clinical examination techniques in children (24) and yet the expert group, representing different training backgrounds, had considerable agreement on the amendments to adult GALS, which were invariably simple maneuvers commonly used in clinical practice. Poor reliability of detailed clinical musculoskeletal assessment among pediatric rheumatologists has been reported (43), but in this study the consultants were compared only on their ability to dichotomize children’s joints as normal or abnormal and showed good level of agreement.

The components of pGALS are demonstrated in Table 2 and Figure 2. The vast majority of children and their parents or guardians deemed pGALS to be acceptable. We did not ascertain the acceptability and discomfort of the pediatric rheumatologists’ examination as part of this study; the few children who deemed pGALS uncomfortable may have also had a similar discomfort when examined by the consultant.

This study involved the testing of pGALS in a pediatric rheumatology clinic and the performance of pGALS by an experienced specialist registrar in adult rheumatology. Assessment of pGALS in routine general pediatric and primary care settings is clearly important, and is planned by our group.

The influence of pGALS on improving clinical skills is

<table>
<thead>
<tr>
<th>Abnormal joints tested, no.†</th>
<th>Normal joints tested, no.†</th>
<th>Sensitivity, %</th>
<th>Specificity, %</th>
<th>Positive predictive value, %</th>
<th>Negative predictive value, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical spine</td>
<td>5</td>
<td>60</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Shoulders</td>
<td>6</td>
<td>124</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Elbows</td>
<td>25</td>
<td>105</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Wrists</td>
<td>42</td>
<td>88</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Hands</td>
<td>26</td>
<td>104</td>
<td>100</td>
<td>99</td>
<td>96</td>
</tr>
<tr>
<td>Temporomandibular joints</td>
<td>27</td>
<td>103</td>
<td>100</td>
<td>98</td>
<td>93</td>
</tr>
<tr>
<td>Lumbar spine</td>
<td>3</td>
<td>62</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Hips</td>
<td>16</td>
<td>114</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Knees</td>
<td>33</td>
<td>97</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Ankles and feet</td>
<td>29</td>
<td>101</td>
<td>97</td>
<td>99</td>
<td>97</td>
</tr>
</tbody>
</table>

* A total of 65 children were tested.
† Joints deemed abnormal or normal by the pediatric rheumatologist.
likely to be greatest if it is taught as a core skill at the undergraduate level. The appropriate interpretation of pGALS requires knowledge of musculoskeletal problems in children and adolescents and awareness of age, developmental changes, and normal variants. This requires supplementary teaching and clinical experience in pediatric rheumatology. Competent performance of pGALS will facilitate a problem-oriented regional examination using an approach similar to adult patients (27). We propose that pGALS be incorporated in routine assessment of all well children and be attempted in unwell children, because significant musculoskeletal problems can manifest in diseases such as sepsis or inflammatory bowel disease. This strategy will raise awareness of musculoskeletal problems in pediatric practice and will facilitate appropriate management, thus optimizing patient care.

ACKNOWLEDGMENTS
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REFERENCES


