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Original article

Neurodynamic responses in children with migraine or cervicogenic headache versus a control group. A comparative study

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Abstract

Headache in children with unknown aetiology is an increasing phenomenon in industrial countries, especially during growth spurts. During this growth phase, the Long Sitting Slump (LSS) can be a useful tool for measurement of neurodynamics and management. This study investigated the difference in cervical flexion and sensory responses (intensity and location) during the LSS tests in children ($n = 123$) aged 6–12 years, between a migraine (primary headache group = PG), cervicogenic headache (secondary headache group = SG) and control group (CG). The results indicated that the intensities of the sensory response rate were highest in the PG and SG when compared to CG. The responses in the legs were predominantly found in the PG (81.9%) and responses in the spine in the SG (80%). The sacrum position varied significantly between both headache groups (PG and SG) and *the CG* ($p<0.0001$), but there was no significant difference between the CG and the PG ($p>0.05$). No significant difference in the neck flexion range was measured in LSS, nor in standardized knee flexion between the PG and CG ($p>0.05$). The cervical flexion ranges differed significantly ($p<0.0001$) between the SG on the one hand and the PG and CG on the other. The biggest difference in neck flexion during knee extension was between the SG and CG.

Keywords: Children; Headache; Migraine; Cervicogenic; Nervous system; Musculoskeletal manipulation

1. Introduction

Chronic pain in children is an increasingly common phenomenon in industrialized countries. Headache is one of the most frequently occurring symptoms (Perquin et al., 2000) and can be classified as follows:

- Primary headache: Headache that manifests without apparent structural disorder and occurs in all age categories. Migraine and tension headache are the most frequently used terms here.
- Secondary headache: The headache is associated with the consequences of structural disorder or pathology such as sinusitis, ear infection, tumours, epilepsy or following (cervicogenic) trauma (Kan et al., 2000; Garcia-Mendez, 2003).

In a cross-sectional study including 2358 children aged between 10 and 17 years, it was found that 21% of the boys and 26% of the girls experienced headache or facial pain once per week on average (Bandell-Hoekstra et al., 2001). A similar study indicated that there has been a 6% increase in the number of children experiencing headache once per week on average between 1985 and 2001 (Passchier and Orlebeke, 1985).

Where the recurrent headache group is concerned, it is often difficult to provide suitable therapy that follows clear guidelines (Perquin et al., 2000; Hershey, 2003; Gladstein, 2004). One of the reasons for this might be

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the difficulty in adequately classifying headache in children. In a study by Maytal et al. (1998), an extensive questionnaire administered to 253 children and adolescents suffering from migraine, was compared to the International Headache Society (IHS) classification. The results showed that 92.4% (high specificity) of the children without migraine were correctly classified, while only 27.3% of the children with migraine (poor sensitivity) were correctly classified. The overall conclusion from this study was that the IHS criteria (IHS, 1988 first edition) could not be adequately applied to children with migraine (Maytal et al., 1998). A similar type of study carried out by Viswanathan et al. (1998) among 150 children in the United Kingdom confirmed these results. Wober-Bingol et al. (1996) investigated the validity of the IHS classification among 156 children and adolescents aged from 6 to 16 years, diagnosed with tension headaches. The findings of the study indicated that the IHS shows only a low sensitivity for tension headaches in children (Wober-Bingol et al., 1996). It would therefore appear that the use of the IHS classification as a diagnostic instrument has only limited usefulness in the particular instance of primary headache in children.

The IHS classification 2004 of secondary headache in section 5 (“Headache attributed to head and/or neck trauma”) and section 11 (“Headache or facial pain attributed to disorders of cranium, neck, eyes, ears, nose, sinus, teeth, mouth or other facial or cranial structures”) is lacking a specific interpretation for children (IHS, 2004). It might be that a number of (unknown) mutually interfering aetiological factors might be the underlying causes here (Kan et al., 2000; Kondev and Minster, 2003). Also included in this category are children with headache as a result of cervicogenic dysfunction. Occipito-atlanto-axial injury has also been cited as a cause of cervicogenic headache in a number of case studies (Sacher, 2003). Such injury might have been sustained prior to or during birth. The significant high-risk factors associated with these injuries are extended labour, forceps delivery, vacuum extraction, caesarean section and multiple births (Biedermann, 2001). Two types of dysfunctions are shown on radiological assessment: a shift of the atlas to one side or extreme rotation of the atlas around the sagital axis (Gutmann, 1983; Biedermann, 1999, 2004). The primary ideas and work are based on clinical observation supported by X-rays in babies and young children (Gutmann, 1983). In the literature clinicians describe different patterns of cervical dysfunctions in early infancy (babies) compared to adults, e.g. extended crying, restlessness, feverishness, intestinal colic, torticollis and cranial asymmetry, opisthotonus, hypotonus and delayed motor development (Biedermann, 2001). From exploratory longitudinal studies of children it appears that more than 40% of these symptoms disappear spontaneously but may return during school years in children from 6 to 12 years. Descriptive literature has estimated that 60% of these children with a history of cervical dysfunctions tend towards a scoliotic posture, general stiffness, “woodenness”, sensory motor retardation, hyperactivity inadequate static and dynamic coordination and a reduced sense of spatial orientation during the years of schooling (Biedermann, 1999, 2004). Frequent headaches are also reported regularly (Terrett and Davies, 2000). Abnormal positioning of the atlas and/or axis is also often found in anterior/posterior (A/P) radiographic images or specialized magnetic resonance (MRI) scans (Biedermann, 1995).

2. The long sitting slump test

The Long Sitting Slump test (LSS) is a modification of the standard slump test in which both legs are placed symmetrically in a bilateral straight leg raise (BSLR) with dorsal flexion of the feet. This test has a good anatomical basis for influencing the entire longitudinal aspect (cranial, dura to filum terminale) of the nervous system (Goddard and Reid, 1965; Adam and Logue, 1971; Breig, 1978; Louis, 1981). A number of similar tests based on measurements of the hamstrings were earlier described. Kendall described the classical responses obtained using this “hamstrings length” test over the various age groups in the 1940s (Kendall, 1948; Kendall et al., 1999). A striking feature was that trunk flexion mobility declined sharply during the 9–14 years of age period and later increased again in adolescence. The explanation given for this was an increasing shortening of the hamstring group. Hamstring flexibility in response to various interventions in the evaluation of the effects of the slump test in healthy adult volunteers and patients with hamstring injury showed variation of hamstrings flexibility which suggests altered tension in the nervous system. This occurs especially during trunk and neck flexion (Johnson and Chiarello, 1997; Turl and George, 1998; Webright et al., 1997).

However, little information is available regarding neurodynamic testing of children. A search of the literature using MEDLINE, COCHRANE and CINAHL employing combinations of the key words: neural, tissue, children, SLR and Slump Test, yielded only two studies. The first was by Idota and Yoshida (1991). Their conclusion from a study of 1244 children aged 7–16 years was that the increased “tension” during the SLR test correlated positively with accelerated skeletal growth. The second was by White and Pape (1992), who investigated the slump test in more than 200 children with central neurological disorders and concluded that the slump test reflects an overall impression of neurodynamic patterns in this group of patients.

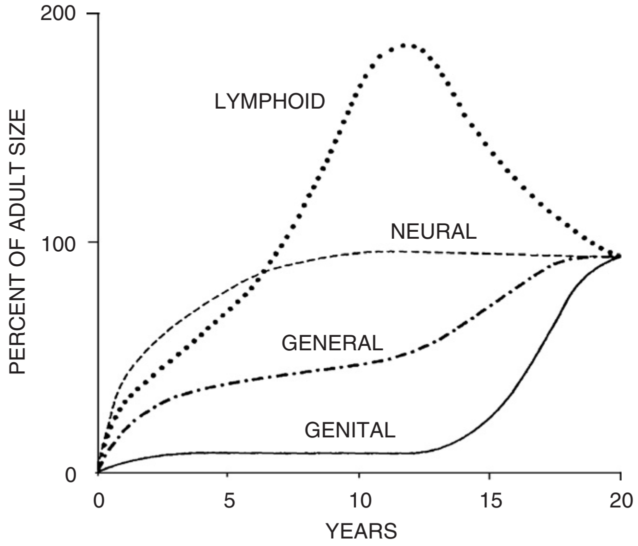

Fig. 1. Percentage of adult-growth attained at 20 years of age (Scammon, 1930).

Functional improvement was positively correlated to the improvement of the Slump Test itself, which could now be carried out easily in a wheelchair (White and Pape, 1992).

Classical growth studies describe the differences in growth rates between nerves, muscles and the skeletal system (Proffit, 1993). A classical survey in this field is that of Scammon, which is still cited as an example even today (Scammon, 1930) (Fig. 1).

In the present study three groups of children aged between 6 and 12 were sequentially subjected to a modified LSS (control group (CG), primary headache and secondary headache groups (PG and SG)) adopting the following hypothesis: clear differences in sensory and physical responses were to be expected in the cervicogenic headache group during the modified LSS when compared to the migraine and CGs. A clear difference was also expected in sensory and physical responses within the two headache groups.

3. Materials and method

3.1. Subjects

A total of 123 children participated in the study in a random sample involving the cooperation of 23 paediatric physiotherapy practices in the Netherlands. Of this group, 44 children (24 male and 20 female) with an average age of 8.5 ± 1.5 were in the CG, 39 children (14 male and 25 female) with an average age of 9.3 ± 1.9 were in the migraine group (PG) and 40 children (19 male and 21 female) with an average age of 7.6 ± 1.5 were in the cervicogenic headache group (SG).

3.2. Inclusion and exclusion criteria

Children in the CG were assessed beforehand by a house- or school doctor. These children had to be free of headache at the time of the study and had never suffered from headaches in the past. They were also required to be without previous history of craniocervical trauma. Children in the migraine group (PG) to have had a headache for a minimum of once a week over a minimum period of six months and also had to comply with the modified IHS classification for children as proposed by Olesen (1997) (see Table 1). Children in the cervicogenic headache group (SG) must have had a headache at least once a week for more than six months. The neck movements of the craniocervical region (C0–C3) were assessed blind for segmental motion and pain by the examiner, with a orthopaedic manual therapy training with 7 years of experience and who was not involved in the rest of the research. This assessment consisted of passive physiological intervertebral motion (PPIVMs) and passive accessory intervertebral motion (PAIVMs) tests (Maitland et al., 2001; Petty and Moore, 2001). When three or more clinical responses such as stiffness and or pain were detected, the child was included in the study. Because the IHS 2004 describes cervicogenic headache (IHS-code M99) in section 11 but it was not related to children and it was impossible to reconstruct all the criteria of the IHS for young children (IHS, 2004), the European Workgroup of Manual Medicine (EWMM) Questionnaire was used. It is a standard measurement for recognition of the clinical pattern of cervicogenic dysfunctions in babies and young infants. The questionnaire, which is only available in German and Dutch, has 37 questions which have to be answered by the parents with "yes" or "no". When

Table 1

Group	Inclusion criteria
Control group (*CG*)	
N = 43	Age 6–12 years
Average age 8.5 (SD 1.8)	No headache in their life
24 male, 19 female	No history of craniocervicogenic dysfunction
Primary headache group (*PG*)	
N = 35	Age 6–12 years
Average age 9.3 (SD 1.9)	At least once a week headache
10 male, 25 female	Criteria adapted classification of the HIS (Olesen, 1997)
Secondary headache group (*SG*)	
N = 39	Age 6–12 years
Average age 7.6 (SD 1.5)	At least once a week headache
18 male, 21 female	Criteria of the EWMM questionnaire has to be fulfilled

Exclusion criteria: all groups had no previous physiotherapeutic healthcare for the last year.

50% or more of the answered questions (19 questions) are answered with “yes”, a history of cervicogenic dysfunction, is moderate to high (Biedermann and Koch, 1996). An English translation of this questionnaire is shown in Table 2. In this study a minimum of 75% (26 questions) or more of the answered questions in the Dutch version of the questionnaire drawn up by the EWMM needed to have been answered in the affirmative. If more than five questions could not be answered, the child was excluded from this study.

Table 2
Anamnestic-questionnaire (EWMM)

1. Your family:	
• Are there any known spinal diseases (e.g. scoliosis, deformities, one leg shorter)	yes/no
• Are there any cervical and lumbar dysfunctions (e.g. neck pain/headaches, migraine)	yes/no
2. Pregnanciest:	
• breech delivery or other abnormal positions	yes/no
• multiple pregnancy	yes/no
2. Birth:	
• forceps, vacuum extractor	yes/no
• Cesarian	yes/no
• Birth traumata	yes/no
4. Particularities:	
• Our child had problems going to sleep	yes/no
• Our child woke up frequently (more than 6 times in a week)	yes/no
• A certain sleeping position was preferred	yes/no
• Breast feeding was difficult on one side	yes/no
• As a baby, our child did not feed well	yes/no
• It was dribbling and spitting a lot	yes/no
• It was screaming a lot	yes/no
• It suffered from 3 months colic	yes/no
• Our child has got a sensitive neck (e.g. when getting dressed)	yes/no
• It keeps pulling his hair	yes/no
5. Other health problems:	
Our child suffered (suffers) from:	
• throat infections	yes/no
• Neurodermatitis	yes/no
• allergies	yes/no
• headaches	yes/no
• Neurological diseases	yes/no
• Our child needs glasses	yes/no
• It keeps its mouth open	yes/no
6. Retarded development	
• Posture and movement	yes/no
• Speech and understanding	yes/no
• Concentration/social competence	yes/no
7. Asymmetry, posture dysfunctions:	
• We have noticed it not immediately after birth	yes/no
• It took a while until we noticed it	yes/no
• Somebody pointed it out to us (doctor, midwife, physiotherapist)	yes/no
9. We particularly noticed that the baby:	
• Only looked to the right/left	yes/no
• Moved only to the right/left	yes/no
• Moves both arms asymmetrically	yes/no
• Moves both legs asymmetrically	yes/no
• The face is smaller on one side	yes/no
• The back of the head seems flat on one side	yes/no
• The back of the head is bald on one side	yes/no

The exclusion criteria for all groups were: no physiotherapy treatment the previous year, no neuromuscular skeletal dysfunctions, amputations, open wounds, etc., present that might affect the measurements.

3.3. *Materials*

The measuring instruments used in this study were the LSS test and a coloured analogue scale (CAS).

A restraining belt was needed for the LSS, which was applied above the knees in order to keep the knees at maximum extension during the test. A specially constructed angle meter with a spring and a goniometer was used for the remaining sacrum position in relation to the horizontal. A Cervical Range of Motion (CROM) apparatus was used for the different flexion measurements of the cervical spine.

The CAS was selected for measuring the intensity of the responses. This analogue scale is a specially designed scale for children age five years and above and was tested for its concurrent and construct validity. It was found to be an accurate and valid measuring instrument for measuring pain in children (McGrath et al., 1996).

4. Examiners

Two researchers participated in the study. Both had been working as physiotherapists for a minimum of three years; one had completed an IFOMT recognized education in manual therapy and the second researcher was at the time of the study in training. Both were given 2 h of training in carrying out a trial of the research procedure and in completing the research protocol. They were then asked to carry out the procedure in their own practices with a minimum of 40 children each. The research procedure and protocol was finally revised in a 60 min meeting four weeks later.

5. Procedure

The modified LSS was assessed for inter-rater reproducibility. Fifteen child volunteers between 7 and 12 years were involved in blind and independent tests by the two researchers. Letters were subsequently sent out to 76 randomly selected paediatric physiotherapy practices in the Netherlands. Twenty-three of these practices were willing to collaborate in the study. The paediatric physiotherapists were given extensive information on the procedure for the study in their own practices. A third research member of staff was available to provide support and answer questions via the internet or by phone. A total of 152 children were invited to take part, of which 29 were unable or unwilling to participate due to illness, alternative arrangements or appointments not kept.

The test procedure was as follows:

- The test subjects were seated in a long sitting position on the couch with feet in active dorsi flexion against a small wooden plank mounted on the couch. A CROM apparatus was placed on the head of the child and calibrated. A restraining belt was placed 10 cm above the base of the patella to ensure that the posterior aspect of the knee made contact with the couch (Fig. 2a).
- The child was asked to flex the trunk actively for 5 s. The position of the sacrum with respect to the horizontal was measured using the specially designed sacrum goniometer (Fig. 2b).
- Active cervical flexion was performed next. The number of degrees was measured by means of the CROM apparatus and the child indicated the intensity and the location of the sensory responses immediately. The intensity was measured by means of the CAS and the location was scored on a five-point scale (head/back/legs/other areas/none). The test subject was required to make a single choice from these categories.
- The same procedure was repeated using a 10 cm high standardized block. The sacrum position during the first test was set and the vertical flexion was measured twice using the CROM apparatus. The measurement of sensory responses was omitted here due to the large amount of information the young test subject was required to process.

Fig. 2. (a) Test position of the LSS in a 8-year-old child. (b) Measurement of the sacrum position during LSS with a specially developed goniometry-set.

6. Statistical analysis

The reproducibility of results between the two testers was analysed by means of an ICC (two-way mixed model with a consistency option). The standard error of measurement (SEM) and the smallest detectable differences were also calculated as expressions of both the reproducibility and the responsiveness of the modified LSS.

Differences between the three groups were tested either by means of ANOVA (with a Tukey–Kramer multiple comparisons test when significant) or a Kruskal–Wallis test (with Dunn post hoc analysis when significant). All calculations were performed in SPSS version 12.01 for Windows or GraphPad Instat version 3.01. The two-sided level of significance was set at 0.05.

7. Results

The reproducibility of the modified LSS test was ICC = 0.96 (95% CI 0.89–0.99). The SEM was 2.83° and the smallest detectable difference was 7.9°. Significant differences in sacrum positions (in degrees) were noted during the execution of the test with the 123 test subjects in both of the headache groups (primary 25.0 SD 4.4, secondary 24.7 SD 5.20) as compared to the CG (30.3 SD 2.6) ($p<0.001$). There was, however, no significant difference between the PG and SG ($p>0.05$).

There was a small, yet statistically significant difference in degrees between the CG (84.7 SD 7.8) and the PG (77.8 SD 1.2) ($p<$ 0.001) for the first neck flexion measurement (NF [a]). There was a greater difference between the CG and the PG, and the CG and the SG (23.0 SD 2.4) ($p<$ 0.001).

The results of the second neck flexion measurement (NF [b]) were 101.1 (SD 8.7) for the CG; 85.2 (SD 12.1) for the PG and 36.2 (SD 1.4) for the SG. There was a statistically significant difference between the CG and the PG ($p<$ 0.001), with a more marked difference between the CG and the PG on the one hand, and the SG on the other ($p<$ 0.001).

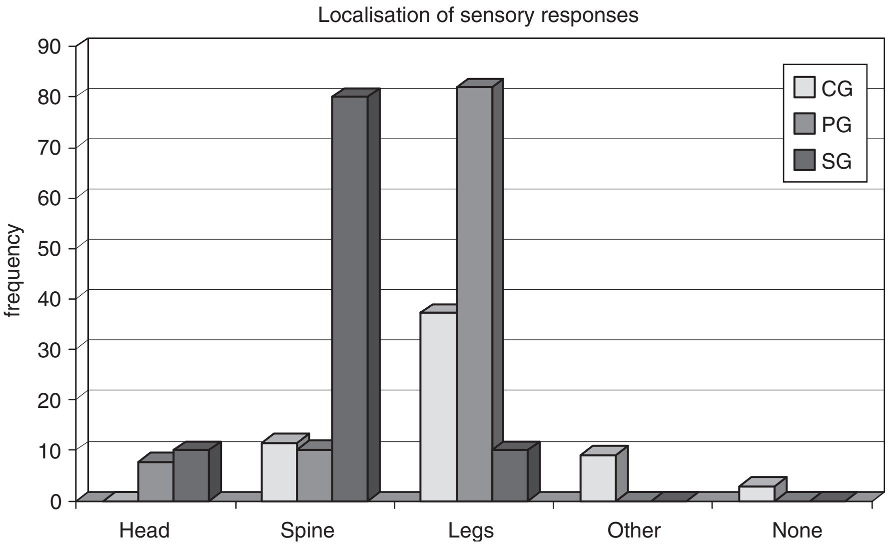

Fig. 3. The frequency and location of the sensory responses during the LSS in the control (CG), primary headache (PG) and secondary headache (SG) group.

The sum of the neck flexion with extension of the knees NF (A) and in knee flexion (NF (b)) was 16.6 (SD 5.7) for the CG, 17.8 (SD 8.6) for the PG and 5.6 (SD 4.7) for the SG. There is a significant difference between the CG and the PG ($p<$ 0.001) and a more marked difference between the PG and the SG ($p<$ 0.001).

The results of the intensity of the sensory responses that were subsequently measured using the CAS were 0.9 (SD 0.85) for the CG and 5.4 (SD 2.3) and 5.5 (SD 1.7), respectively, for the PG and SG. The difference between both headache groups and the CG was significant ($p<0.05$), whilst there were no significant differences between the two headache groups.

In 82% ($n=29$) of the PG, the sensory response was clearly felt in the legs. In 80% ($n=31$) of the SG, the sensory responses were felt particularly in the spinal column (Fig. 3). In the CG 36% of the responses were felt in the legs ($n=15$) while 46% ($n=20$) felt absolutely nothing during the LSS. A total of 18% ($n=12$) of the test subjects felt their responses in the head, five of these children being in the PG and seven in the SG. In only two children belonging to the PG and three children belonging to the SG did the responses coincide with what for them was their "well-known" headache.

8. Discussion

In the present study the EWMM Questionnaire was used for detecting cervicogenic aetiology in babies and infants. The authors of this questionnaire (Biedermann and Koch, 1996) performed a prospective study of more than 1000 babies and young children up to the age of five. By defining the symptoms together with abnormal positioning of the atlas and/or axis by A/P radiography images the questionnaire was completed retrospectively. As far as the authors know it is the only questionnaire in this field. Therefore, we restricted the inclusion to those children who answered a minimum of 75% of the questions with "yes", and excluded children if their parents could not answer "yes" or "no" to five or more questions.

The release of dorsi flexion of the feet in the LSS position was the movement of choice to provide support for the existence of a neurodynamic mechanism (Beith et al., 1995; Butler, 2000; Shacklock, 2005) in the subjects tested. During the trials, in which a pilot study ($n=40$) was performed before the study, application of dorsi flexion resulted in increased sensory responses in most children (76%) when this was combined with the experimental posture changes. Maintaining the standardized sacrum position and measurement of the cervical flexion by the CROM during this dorsi flexion manoeuvre was impossible. Therefore, a 10 cm high standardized block under the knees was suggested as a structural differentiation manoeuvre.

There was statistically significantly more cervical flexion in the PG than in the SG in both the extension and flexion phases during the LSS position. The sensory responses in the PG were predominantly in the legs and in the SG these responses were mainly indicated as being in the spinal column with a statistically significantly higher intensity than in the CG. This suggests different pathophysiological mechanisms in both headache groups. From animal studies and through mechanisms of nociception and neurogenic inflammation, it is thought that movement of the dura may evoke pain (Groen et al., 1988; Kumar et al., 1996; Bove and Moskowitz, 1997) and neurogenically inflamed (craniocervical) dura may lead to changes of the contractile state of the blood vessels in the head which may lead to headache (Moskowitz, 1993).

The present study concerns itself with children who experience distinct headaches at least once a week. From a prevalence study by Van Duin et al. (2000) among 1254 children between 6 and 16 years, it appears that such children account for 9% of all children studied. These are also children who regularly need medical help (Van Duin et al., 2000), a fact that increases the likelihood that they will see a number of help-providers, including manual therapists. During the study it was interesting that the cervical flexion of the SG during the knee flexion phase improved less than in the case of the PG and the CG. This may be explained by anatomical differences. It is postulated that the majority of the cervical flexion (even in children) takes place between the atlas and axis (Gutmann, 1983; Biedermann, 1999). The atlas is not attached to the dura as a rule, which means that the neurodynamic positions have less influence on the arthrokinematics of the atlas (Gutmann, 1983; Lang and Kehr, 1983). This does not mean that it can be concluded that neurodynamic effects on cervical flexion in the SG can be ruled out. Clear differences in the intensity of the local responses measured using the CAS were observed in the CG on the one hand and in both headache groups on the other. This confirms observations in the literature that children with recurrent headaches generally have increased levels of sensitivity (McGrath and Koster, 2001), but it may also be related to changed neurodynamics which contributes to a higher neural sensitivity (Groen et al., 1988; Bove and Moskowitz, 1997).

9. Conclusion

This study showed clear differences between measurements (neck flexion, location and intensity of sensory responses) of a modified LSS in a PG, SG and CG of children between the ages of 6 and 12 years. These results suggest (i) different pathophysiological mechanisms of headache and (ii) different biomechanical patterns of the craniocervical region. Further research of these mechanisms is required to optimize assessment and management strategies.

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