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A photographic method for multi-plane assessment of adolescent posture

Filadelfio Puglisi[1], Paolo Donati[1], Mirca Marini[2*], Loris Romeo[1], Stefano Scidone[1], Robert Ferrari[3]

[1] Laboratorio della Postura. ISIS Leonardo da Vinci, Florence, Italy
[2] Department of Experimental and Clinical Medicine, Section of Anatomy and Histology, University of Florence, Florence, Italy
[3] Department of Medicine and Department of Rheumatic Diseases, University of Alberta, Edmonton, Alberta, Canada

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Abstract

To date there have been no photographic methods reported for assessing the standing postural alignment in a manner that can be used in large scale populations. The purpose of this study was to describe a photographic, multi-plane postural measurement method in a pilot group of subjects in a school setting. A total of 83 healthy male adolescents, volunteered for the study, were photographed. The mean age was 14.5 ± 0.7 years (range 14 – 16). The mean height was 170.7 ± 3.5 cm, (range 155 – 187), and the mean weight was 63.2 ± 13.9 kg (range 37 – 110). During procedure, subjects stood on a platform, with specific markers placed on landmarks that could be identified photographically. Photography was accomplished from above, below, each side, and front and back. These six photographs permit views to be projected onto the six sides of an ideal parallelepiped enclosing the body. Five angles were calculated and reported to describe the alignments of the head, shoulders, torso, and pelvis. As expected the means of each of the five angles were small, the absolute value varying from 0 to 7 degrees. This paper describes the results of a simple, practical, and effective way to gather data concerning standing postural alignment in adolescents using a photographic technique. This technique will be used to form a normative database by large-scale studies. Using this approach, a number of angles can be calculated and eventually models can be developed, relating these angles to sitting posture measurements and to symptoms.

Key words

Posture, adolescence, photography, back pain, neck pain, scoliosis.

Introduction

A number of studies have reported on the increasing prevalence of back pain among school age children and adolescents (Harreby et al., 1999; Watson et al., 2002; Jones et al., 2003). Low back pain in adolescence has high prevalence (Ebrall, 1994) and recurrence rates (Burton et al., 1996; Taimela et al., 1997) that increase with age (Balague et al., 1994; Leboeuf-Yde and Kyvik, 1998; Watson et al., 2002), and is associated with the recurrence of low back pain through adultlife (Harreby et al., 1995; Brattberg, 2004; Kopecand and Sayre, 2005). In adolescence, prevalence rates for

* Corresponding author. E-mail: mirca.marini@unifi.it.

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chronic low back pain are documented as 8% (Salminen et al., 1999; Bejia et al., 2005) with the majority of these disorders classified as nonspecific chronic low back pain (O'Sullivan, 2004, 2005).

There is a need for research into the early stages of the problem. One area of investigation has been the measurement of static postures and alignment in the sitting and standing positions. Astfalck et al. (2010) showed that spinal posture in usual and slump sitting were similar for adolescents with and without non specific chronic low back pain, but differences were identified in both sitting conditions when subjects with pain were sub-classified and compared with controls. Geldhof et al. (2007) also showed that sitting posture may be a factor in symptoms. This observation at least brings forward the possibility that there are some postural alignments or relationships that can be measured and can be associated with symptoms, but the degree to which these measures explain the variance in the primary variable of interest (the presence of absence of low back pain) remains low. One possibility is that sitting posture alone is not the best, or the only relevant measure. Sitting posture may be affected by other postural alignments, which in turn may be more evident when examined in the standing position.

Standing postural alignments and relationships may interact with other spinal pain risk factors such as sitting in the classroom (O'Sullivan et al., 2006; Straker et al., 2008). Thus, there have been a number of attempts to measure standing posture and alignments. In the context of school-age children and adolescents, posture measurements in research should be relatively simple, appropriate, cost-effective and readily available in a school setting.

As reviewed by Perry et al. (2008), a wide range of methods have been used to objectively assess spinal posture, including X-rays (Jackson et al., 2000) three-dimensional motion analysis using electromagnetic and optical devices (Straker et al., 2008), raster-stereography (Asher et al., 2004), photographic analysis (McEvoy and Grimmer, 2006), and manual measurement. While X-rays allow clear visualization of bony landmarks, radiation hazards preclude its widespread use in research studies. Electromagnetic motion analysis techniques have been reported to be valid (Sprigle et al., 2002) and reliable (Lissoni et al., 2001). However, this method requires expensive equipment and is time-consuming. Video raster-stereography involves the multidirectional illumination of the back surface during stereo video imaging to produce a high-resolution three-dimensional computer reconstruction of the back surface (Goh et al., 1999). This method has the disadvantage of requiring the entire torso to be uncovered, which is not acceptable in adolescents. It is also, like the aforementioned methods, expensive. Some manual measurement techniques, such as the pelvic goniometer (Sprigle et al., 2003) and flexicurve (Hart and Rose, 1996) have also been shown to be valid, and some are reliable for adults (Hickey et al., 2000; Engh et al., 2003). Perry et al. (2008) have argued that the use of X-rays, motion analysis, raster-stereography or manual methods are not appropriate for large-scale studies when measuring multiple angles, because of difficulties in application, expense, or safety.

In a school setting, where monitoring of posture and large scale research projects may be undertaken, static photographic analysis with reflective markers placed on specified anatomical landmarks may be more suitable. The approach is relatively inexpensive, requiring only a camera and markers. The technique can readily take place in a school setting and permits the measurement of several posture planes. It is thus frequently used in field and clinical studies (Refshauge et al., 1994; Grimmer et al, 2002; Dunk et al., 2005; Straker et al., 2007).

There have been several reports of the reliability of sagittal photographic analysis of spinal posture in adults (Braun and Amundson, 1989; Watson and Trott, 1993; Raine and Twomey, 1994; Refshauge et al., 1994; Johnson, 1998; Kietrys et al., 1998; Dunk et al., 2004; Dunk et al., 2005). While Perry et al. (2008) have provided data on multiple angles measured in the sagittal plane for adolescents, there have been, to date, no reported attempts to measure multiple planes in adolescents in a manner that is efficient, inexpensive and relatively simple.

This report describes a photographic, multi-plane postural measurement method in a pilot group of 83 male adolescent subjects in a school setting.

Materials and Methods

Subjects

Adolescent male subjects were recruited, upon advertisement, from a single secondary school in Florence, Italy. Exclusion criteria were the recall of any spinal pain or headache in the last 3 months, known visual deficits, balance disorders, or being non-ambulatory. The cohort was a sample of students enrolled in the first year of a technical industrial school, Leonardo Da Vinci School of Florence. Only males were chosen as there were very few female students. Approximately 400 students were enrolled in the first year. Our goal was to recruit at least 75 subjects for this pilot study. All subjects and guardians/parents gave informed consent. All procedures were in accordance with the Helsinki Declaration of 1975, as revised in 1983.

Procedure

The subjects were studied individually, dressed in shorts. One examiner (FP) performed all the measurements on each subject. The examiner placed black (round-shaped, button-sized) markers with double-sided tape on the following landmarks: acromions, C7 spinous process, and superior anterior iliac spines. The subjects stood on a platform (see Figure 1), facing a marker on a wall that they were asked to stare at. This placed the subject directly in front of the camera. A frontal (flash) photograph was taken, than another photograph was taken from above with a webcam and from below with a podoscope. Then the subjects rotated 90 degrees to their left for another photograph, and then 180 degrees to their right. This allowed for lateral views. The subjects, in each case, were given a mark on the opposing wall to stare at. Subjects then rotated again to have their back facing the camera, for another photograph. These six photographs permit views to be projected onto the six sides of an ideal parallelepiped enclosing the body (Fig. 1).

The equipment consisted of a single digital camera (Cyber-Shot 14 MP; Sony, Tokyo, Japan) for the frontal and lateral photographs (Fig. 2). The camera was placed on a tripod 80 cm high and 280 cm distant from the subject. The two transverse views were taken respectively with a webcam (Logitech HD Pro; Logitech, Karachi, Pakistan) fixed to the ceiling and a podoscope (made from a Lide scanner; Canon, Tokyo, Japan) which had the top plate reinforced with a perspex plate 2.5 cm thick.

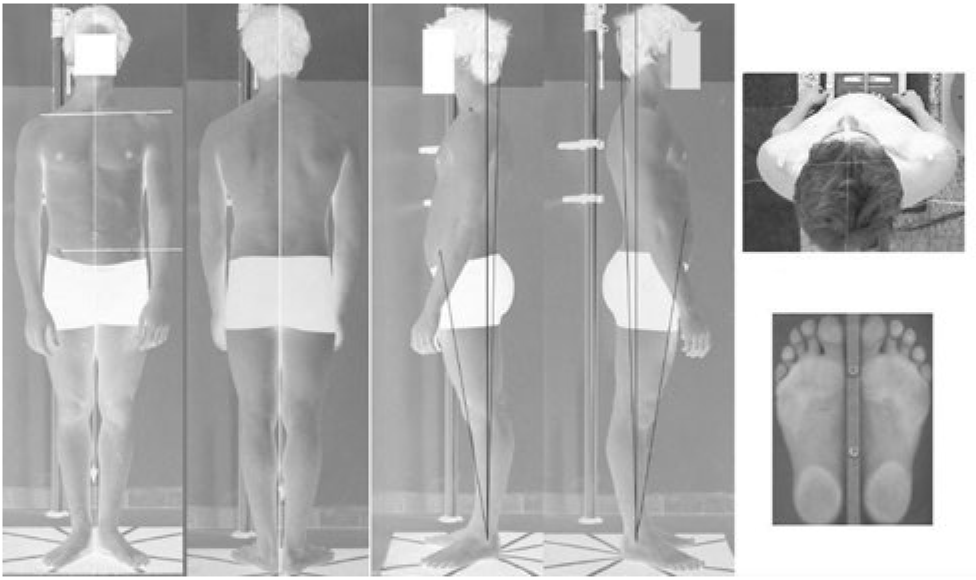

Figure 1 – Directions of photographs.

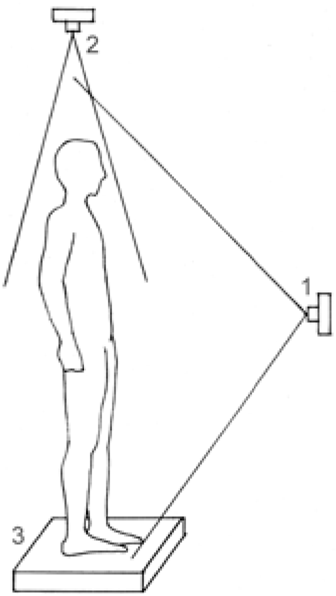

Figure 2 – Experimental set-up and positioning of cameras relative to subject.

Image processing

Each digital image was analysed using Paint Shop 7. This software was chosen because of its wide availability and relative ease of use. First, lines were drawn to indicate the X, Y, and Z axis for each subject. The origin of axes is the geometrical centre of the foot support area. The Z axis is vertical. X is perpendicular to Z and defines the sagittal plane XZ. Y is perpendicular to both X and Z and defines the frontal plane YZ. These planes are shown in Figures 3 and 4. Using the landmarks described, one is able to draw additional lines that allow to calculate the following angles:

- Angle A: between the axis bisecting the head and the X axis.
- Angle B: between the biacromial axis and the Y axis.
- Angle C: between the axis bisecting the head and an axis perpendicular to the acromion line. This angle is assumed to give the amount of rotation of neck relative to shoulders (Fig. 3).
- Angle D: between the biacromial axis and the horizontal plane (Fig. 4).

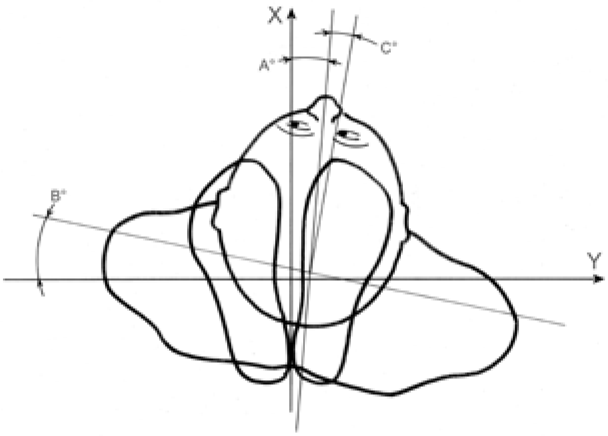

Figure 3 – Method of drawing for calculation of angles A, B, C.

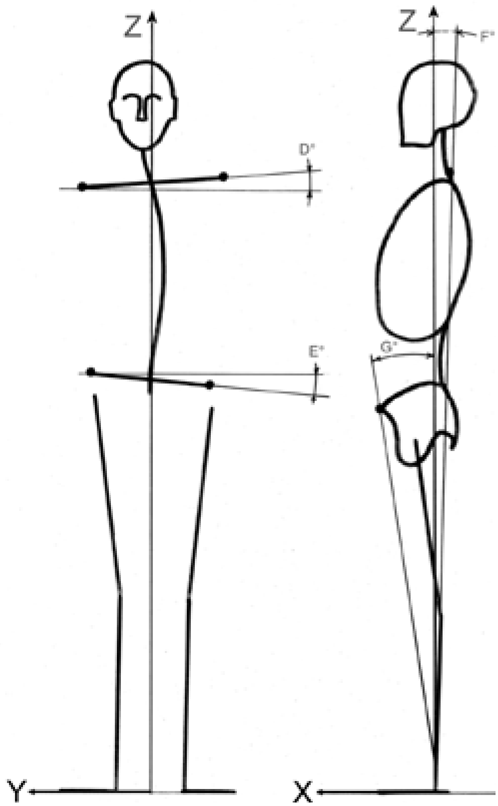

Figure 4 – Method of drawing for calculation of angles D, E, F, G.

- Angle E: between the line between the two superior anterior iliac spines and the horizontal plane (Fig. 4).
- Angle F: between the line from C7 to the external malleolus and the Z axis (Fig. 4).
- Angle G: between the line from the external malleolus to the superior anterior iliac spine and the Z axis (Fig. 4).

Angles A and B are not relevant in the sense that they simply reflect the extent to which the subject rotated on the Z axis when standing. Angle C reflects the degree of rotation between the head and the shoulders; it can be calculated from A and B. Angle C is correlated with the strain on neck muscles for keeping the gaze aligned and angle B with trunk torsion relative to feet. The latter could be of interest for scoliotic subjects, but was not the subject of the current study. Angles D and G are included here for completeness, although they do not have any specific clinical correlate at this time.

Statistics

Descriptive statistics were calculated for the cohort. The mean, standard deviation, and range for each of 7 angles were also calculated.

Results

At total of 83 male subjects were photographed. The mean age was 14.5 ± 0.7 years (range 14-16). The mean height was 170.7 ± 3.5 cm (range 155 – 187) and the mean weight was 63.2 ± 13.9 kg (range 37 – 110).

The mean, standard deviation, and range of the five angles measured are shown in Table 1. As can been seen, the greatest deviation from zero was observed for angle G, as expected from anatomy, while all other angles were small and zero value was part of the range.

Discussion

This paper describes the results of a simple, practical, and effective way to gather data concerning standing postural alignment in adolescents using a photographic

Table 1 – Mean, range, and standard deviation of absolute values of angles C through G. Angles A and B were used only for calculating angle C and are not shown in the table. The number of sample units was 83.

Angle	Mean, in degrees (range)
C	2.4 ± 1.7 (0 - 7.2)
D	1.5 ± 1.2 (0 - 4.5)
E	1.4 ± 1.1 (0 - 4.3)
F	2.3 ± 1.0 (0.4 - 4.3)
G	7.4 ± 1.4 (5.8 - 9.4)

technique. Using this approach a number of angles can be calculated and models can be developed, relating these angles to sitting posture measurements and to symptoms. In this cohort, the subjects were asymptomatic and all the angles are small, varying from 0 to 4 degrees. The goal is to develop a normative database with hundreds of asymptomatic subjects, and then compare these values with cohorts of symptomatic subjects, to assess if they show significant differences in their mean angle measurements or in combinations thereof. The goal of interventions, be it posture awareness, ergonomic interventions or exercise, will be to correct anomalous angles and verify if this improves symptoms, which would support the hypothesis that mal-alignments are indeed indicators of underlying problems resulting in symptoms. This is the first study to our knowledge where the horizontal plane has been systematically measured in photographs from above, giving an evaluation of trunk and head torsion.

There are limitations with this approach. First, it does not assess the sitting posture; Perry et al. (2008) have developed an approach to this position that could be combined with the presently proposed approach to standing position. Second, we have yet to determine the inter-examiner and intra-examiner coefficients for both the photographic and digital analysis component. It is also not clear how much these angles will vary in a given individual over repeated measures in a short time span.

However the present results show that this approach is applicable to large scale studies in environments like schools, is cost-effective, and may be readily combined with other photographic techniques.

References

Asher M., Min-Lai S., Burton D., Manna B. (2004) The influence of spine and trunk deformity on preoperative idiopathic scoliosis patients' health related quality of life questionnaire responses. Spine 29: 861-868.

Astfalck R.G., O'Sullivan P.B., Straker L.M., Smith A.J., Burnett A. Caneiro J.P., Dankaerts W. (2010) Sitting postures and trunk muscle activity in adolescents with and without nonspecific chronic low back pain. An analysis based on subclassification. Spine 35: 1387-1395.

Balague F., Noordin M., Skovron M.L., Dutoit G., Yee A., Waldburger M. (1994) Nonspecific low-back pain among school children: a field survey with analysis of some associated factors. J. Spinal Disord. 7: 374-379.

Bejia I., Abid N., Ben Salem K., Letaief M., Younes M., Touzi M., Bergaoui N. (2005) Low back pain in a cohort of 622 Tunisian school children and adolescents: an epidemiological study. Eur. Spine J. 14: 331-336.

Brattberg G. (2004) Do pain problems in young school children persist into early adulthood? A 13-year follow-up. Eur. J. Pain. 8: 187-199.

Braun B.L., Amundson L.R. (1989) Quantitative assessment of head and shoulder posture. Arch. Phys. Med. Rehabil. 70: 322-329.

Burton A.K., Clarke R.D., McClune T.D., Tillotson K.M. (1996) The natural history of low back pain in adolescents. Spine 21: 2323-2328.

Dunk N.M., Chung Y.Y., Compton D.S., Callaghan J.P. (2004) The reliability of quantifying upright standing postures as a baseline diagnostic clinical tool. J. Manip. Physiol. Ther. 27: 533-534.

Dunk N.M., Lalonde J., Callaghan J.P. (2005) Implications for the use of postural analysis as a clinical diagnostic tool: reliability of quantifying upright standing spinal postures from photographic images. J. Manip. Physiol. Ther. 28: 386-392.

Ebrall P.S. (1994) The epidemiology of male adolescent low back pain in a north suburban population of Melbourne, Australia. J. Manip. Physiol. Ther. 17: 447-453.

Engh L., Fall M., Henning M., Soderlund A. (2003) Intra- and inter-rater reliability of goniometric method of measuring head posture. Physiother. Theory Pract. 19: 175-182.

Geldhof E., De Clercq D., De Bourdeaudhuij I., Cardon G. (2007) Classroom postures of 8–12 year old children. Ergonomics 50: 1571-1581.

Goh S., Price R., Leedman P., Singer K. (1999) Rasterstereographic analysis of the thoracic sagittal curvature. A reliability study. J. Musculoskel. Res. 3: 137-142.

Grimmer K., Brenton D., Milanese S., Pirunsan U., Trott P. (2002) Adolescent standing postural response to backpack loads: a randomised controlled experimental study. BMC Musculoskel. Dis. 3: 10

Harreby M., Neergaard K., Hesselsoe G., Kjer J. (1995) Are radiologic changes in the thoracic and lumbar spine of adolescents risk factors for low back pain in adults? A 25-year prospective cohort study of 640 school children. Spine 20: 2298-2302.

Harreby M., Nygaard B., Jessen T., Larsen E., Storr-Paulsen A., Lindhal A., Fisker I., Laegaard E. (1999) Risk factors for low back pain in a cohort of 1389 Danish school children: an epidemiologic study. Eur. Spine J. 8: 444-450.

Hart D.L., Rose S.J. (1986) Reliability of a noninvasive method for measuring the lumbar curve. J. Orthop. Sports Phys. Ther. 8: 180-184.

Hickey E.R., Rondeau M.J., Corrente J.R., Abysalh J., Seymour C.J. (2000) Reliability of the Cervical Range of Motion (CROM) device and plumb-line techniques in measuring resting head posture (RHP). J. Man. Manip. Ther. 8: 10-17.

Jackson R.P., Kanemura T., Kawakami N., Hales C. (2000) Lumbopelviclordosis and pelvic balance on repeated standing lateral radiographs of adult volunteers and untreated patients with constant low back pain. Spine 25: 575-586.

Johnson G.M. (1998) The correlation between surface measurement of head and neck posture and the anatomic position of the upper cervical vertebrae. Spine 23: 921-927.

Jones G.T., Watson K.D, Silman A.J., Symmons D.P.M., MacFarlane G.J. (2003) Predictors of low back pain in British schoolchildren: a population-based prospective cohort study. Pediatrics 111: 822-828.

Kietrys D.M., McClure P.W., Fitzgerald G.K. (1998) The relationship between head and neck posture and VDT screen height in keyboard operators. Phys. Ther. 78: 395-403.

Kopec J.A., Sayre E.C. (2005) Stressful experiences in childhood and chronic back pain in the general population. Clin. J. Pain 21: 478-483.

Leboeuf-Yde C., Kyvik K.O. (1998) At what age does low back pain become a common problem? A study of 29,424 individuals aged 12–41 years. Spine 23: 228-234.

Lissoni A., Caimmi M., Rossini M., Terenghi L. (2001) Threedimensional analysis of the sitting posture. Europa Medicophysica 37: 101-109.

McEvoy M.P., Grimmer K. (2005) Reliability of upright posture measurements in primary school children. BMC Musculoskel. Dis. 6: 35

O'Sullivan P. (2005) Diagnosis and classification of chronic low back pain disorders: maladaptive movement and motor control impairments as underlying mechanism. Man. Ther. 10: 242–255.

O'Sullivan P.B. (2004) 'Clincal instability' of the lumbar spine: its pathological basis, diagnosis and conservative management. In: Jull G.A., Boyling J.D., eds. Grieve's Modern Manual Therapy: The Vertebral Column. 3rd ed, Churchill Livingstone, Edinburgh. Pp. 311-331.

O'Sullivan P.B., Mitchell T., Bulich P., Waller R., Holte J. (2006) The relationship between posture and back muscle endurance in industrial workers with flexion-related low back pain. Man. Ther. 11: 264-271.

Perry M., Smith A., Straker L., Coleman J., O'Sullivan P. (2008) Reliability of sagittal photographic spinal posture assessment in adolescents. Adv. Physiother. 10: 66-75.

Raine S., Twomey L.T. (1994) Posture of the head, shoulders and thoracic spine in comfortable erect standing. Aust. J. Physiother. 40: 25-32.

Refshauge K., Goodsell M., Lee M. (1994) Consistency of cervical and cervicothoracic posture in standing. Aust. J. Physiother. 40: 235-240.

Salminen J.J., Erkintalo M.O., Pentti J., Oksanen A., Kormano M.J. (1999) Recurrent low back pain and early disc degeneration in the young. Spine 24: 1316-1321.

Sprigle S., Flinn N., Wootten M., McCorry S. (2003) Development and testing of a pelvic goniometer designed to measure pelvic tilt and hip flexion. Clin. Biomech. 18: 462-465.

Sprigle S., Wootten M., Bresler M., Flinn N. (2002) Development of a noninvasive measure of pelvic and hip angles in seated posture. Arch. Phys. Med. Rehabil. 83: 1597-1602.

Straker L., Burgess-Limerick R., Pollock C., Murray K., Netto K., Coleman J., Skoss R. (2008) The impact of computer display height and desk design on 3D posture during IT work by young adults. J. Electromyogr. Kinesiol. 18: 336-349.

Straker L.M., O'Sullivan P.B., Smith A., Perry M.C. (2007) Computer use and habitual spinal posture in Australian adolescents. Public Health Rep. 122: 634-643.

Taimela S., Kujala U.M., Salminen J.J., Viljanen T. (1997) The prevalence of low back pain among children and adolescents. A nationwide, cohort-based questionnaire survey in Finland. Spine 22: 1132-1136.

Watson D.H., Trott P.H. (1993) Cervical headache: an investigation of natural head posture and upper cervical flexor muscle performance. Cephalalgia 13: 272-284.

Watson K.D., Papageorgiou A.C., Jones G.T., Taylor S., Symmons D.P.M., Macfarlane G.J. (2002) Low back pain in school children: occurrence and characteristics. Pain 97: 87–92.