*Joanna Chowańska[1, 2], Tomasz Kotwicki[1, 2], Krzysztof Rosadziński[2]

Comparison of standing and sitting position used in surface topography trunk assessment**

Porównanie pozycji stojącej i siedzącej przy ocenie deformacji skoliotycznej tułowia techniką topografii powierzchni ciała

[1]Rehasport Clinic, Poznań
Head of the Clinic: Witold Dudziński, MD, PhD
[2]Spine Disorders Unit, Department of Pediatric Orthopedics and Traumatology, University of Medical Sciences, Poznań
Head of the Department: Prof. Andrzej Szulc, MD, PhD

Summary

Introduction. Children with idiopathic scoliosis need x-ray rechecks. Adams test and Angle of Trunk Rotation (ATR) measurement with Bunnell scoliometer are standard methods of trunk assessment. Surface topography examination (ST) enables three-dimensional, fast and accurate trunk analysis. This study was conducted to evaluate a sitting position with trunk kyphotization in ST examination (ST-Sit) used for assessment of scoliotic patients' trunk deformations.

Material and methods. 113 girls were examined, aged 10 to 18, mean 14.0 ± 2.1. Cobb angle mean value was 41.2° ± 16.7°, ranged from 10° to 95°. Based on x-ray imaging, ATR scoliometer measurement and ST examination, the following parameters were assessed: spinal length, POTSI, Hump Sum and number of spinal curvatures in frontal plane.

Results. ST revealed statistically significant difference between standing and sitting position regarding: spinal length, POTSI and Hump Sum. Strong correlation occurred between Hump Sum parameters measured with scoliometer and during standing position in ST (ST-Stand). Hump Sum results of scoliometer examinations and ST-Sit revealed very strong correlation. There was no statistically significant difference between rotational values measured with scoliometer and during ST-Sit. Higher number of spinal curvatures was detected in ST-Sit compared to X-ray examination and ST-Stand.

Conclusions. ST-Sit position (1) is easy to perform, (2) more stable than ST-Stand, (3) eliminates influence of pelvis asymmetry on trunk, (4) correlation between scoliometer measurement and ST-Sit was stronger than between scoliometer measurement and ST-Stand, (5) trunk kyphotization allows higher sensitivity of rotational deformity evaluation (6) and better visualization of spinal curvatures.

Key words: idiopathic scoliosis, Bunnell scoliometer, surface topography

Streszczenie

Wstęp. U dzieci ze skoliozą okresowo wykonywane jest badanie rentgenowskie (RTG), standardowo stosuje się test Adamsa, połączony z pomiarem Kąta Rotacji Tułowia (KRT) skoliometrem Bunnella. Badanie topografii powierzchni ciała (TPC) umożliwia szybką i dokładną analizę postawy ciała w trzech płaszczyznach przestrzeni. Celem pracy było zbadanie użyteczności pozycji siedzącej z kifotyzacją tułowia w badaniu TPC.

Materiał i metody. Przebadano 113 dziewcząt ze skoliozą idiopatyczną w wieku od 10 do 18 lat, średnia 14,0 ± 2,1 lata. Wielkość skrzywienia wynosiła 41,2° ± 16,7° (od 10° do 95° kąta Cobba), test Rissera od 0 do 5, mediana 2.

Na podstawie badania RTG, skoliometrem oraz TPC w pozycji stojącej i siedzącej oceniano następujące parametry: długość kręgosłupa, POTSI, Hump Sum, liczba łuków skrzywienia.

Wyniki. W badaniu TPC wykazano znaczącą statystycznie różnicę wyników uzyskanych w pozycji stojącej w porównaniu z pozycją siedzącą w odniesieniu do parametrów: długość kręgosłupa, POTSI i Hump Sum. Korelacja sumy rotacji tułowia ocenianej skoliometrem- HumpSum(sk) oraz metodą TPC – HumpSum(tp) w pozycji stojącej była silna, a w pozycji siedzącej była bardzo wysoka. Różnica pomiędzy średnią wartością rotacji tułowia oceniana skoliometrem i metodą TPC w pozycji siedzącej nie była istotna statystycznie. Największą liczbę łuków stwierdzono w badaniu TPC w pozycji siedzącej.

Wnioski. Badanie TPC może być z powodzeniem prowadzone w pozycji siedzącej. Pozycja ta: (1) jest łatwa do przyjęcia, (2) stabilna, (3) eliminuje problem asymetrycznego ustawienia miednicy, (4) wykazuje większą korelację z badaniem przy użyciu skoliometru niż pozycja stojąca, (5) kifotyzacja tułowia zwiększa czułość badania TPC na wartość rotacji oraz (6) umożliwia lepsze uwidocznienie łuków skrzywienia.

Słowa kluczowe: skolioza idiopatyczna, skoliometr Bunnella, topografia powierzchni ciała

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INTRODUCTION

Idiopathic scoliosis is a developmental deformity of spine and trunk of unknown etiology. Three-dimensional deformity of the spine consists of: lateral spine bend in frontal plane, disturbances in physiological spine curvatures in sagittal plane: thoracic kyphosis and lumbar lordosis as well as axial rotation of vertebrae in horizontal plane (1). Spinal distortion changes the alignment of ribs attached to the spine and causes deformation of the thorax (fig. 1). Asymmetric mechanical forces: pressure, gravitation, pulling caused by ligaments, tendons and muscles lead to bone remodeling and three-dimensional structural changes, which is described as a torsion (1, 2).

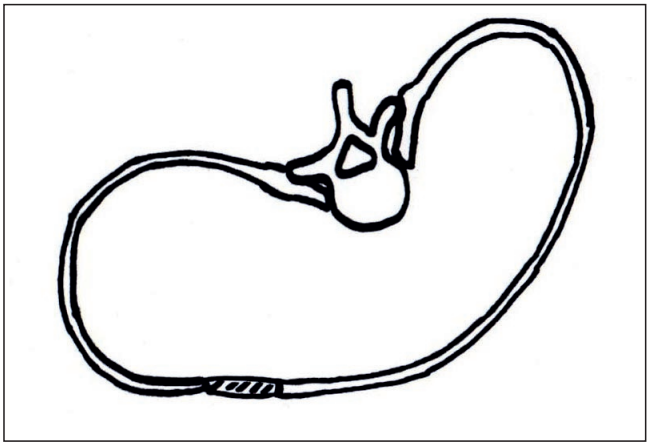


Fig. 1. Scoliotic patient's thorax transverse section (scheme).

Children and adolescents need to be regularly followed up in order to detect scoliosis progression. Clinical examination and periodic x-rays are used in trunk deformation assessment. Adams test combined with Angle of Trunk Rotation measurement done with the use of Bunnell scoliometer are used conventionally. Forward bending of trunk reveals vertebrae rotation appearing as a rib hump at thoracic level and/or muscle prominence at lumbar level. Vertebrae spinal processes alignment is changed during the bend, which makes the curvatures more visible (fig. 2A).

Non-invasive optical techniques for trunk shape assessment, known as surface topography (ST), have aroused interest lately. Those methods are based on the relationship between the angle of spinal curvature and visible surface deformity (3-6). The use of computer technology in the surface topography examination enables fast and accurate three-dimensional trunk shape analysis as well as data storage and comparison (fig. 2B). Both clinical and ST trunk assessment are performed in standing position of the patient.

The aim of the study was to evaluate the usefulness of sitting position during ST examination used for assessment of deformity resulting from idiopathic scoliosis.

MATERIAL AND METHODS

113 girls aged from 10 to 18 years, mean 14.0 ± 2.1 years old, were examined. The height of the girls was 160.0 ± 9.4 cm (from 121 to 184 cm), mean body weight was 48.6 ± 9.2 kg (from 22 to 75 kg). The mean value of the main spinal curve, measured with the use of Cobb method was 41.2° ± 16.7° (from 10° to 95°). Results of Risser test ranged from 0 to 5, median 2.

The number of spinal curvatures and their Cobb angles were determined, based on x-ray exams.

The magnitude of a rib hump and lumbar prominence was assessed with the use of Bunnell scoliometer. Based on scoliometer examination results, the value of Hump Sum(sk) parameter was calculated. It was done by adding the greatest values of ATR of the main and – if occurred – of compensatory curvatures, as shown in the algorithm (fig. 3) (7).

Fig. 2. Non-invasive methods of objective evaluation of trunk deformity in idiopathic scoliosis: A – ATR measurement with the use of Bunnell scoliometer (forward bending standing position), B – surface topography examination (relaxed standing position).

ST examination was performed in two positions of the patient: (1) relaxed standing and (2) sitting with trunk kyphotization, lower extremities with knee and hip joints bent at about 90°, shoulder girdle above a pelvis and arms embracing the knees (fig. 4).

The following ST parameters were analyzed: number of spinal curvatures, length of the spine measured from the spinal process of the seventh cervical vertebra to the spinal process of the first sacral vertebra, Posterior Trunk Symmetry Index: POTSI (7, 8, 9), ST sum of rotation: Hump Sum(st) (7) (fig. 5).

According to the scheme presented in table 1, examinations results were compared.

Furthermore, ten children were examined in order to analyze five options of the sitting position in terms of: stability and usefulness for the ST examination purpose.

RESULTS

The following parameters of ST examination in standing and sitting positions: length of the spine from C7 to S1, POTSI and Hump Sum(st) are shown in table 2.

Correlation of Hump Sum(sk) and Hump Sum(st) in standing position was strong (fig. 6).

Correlation of Hump Sum(sk) and Hump Sum(st) in sitting position was very strong (fig. 7).

The difference between mean values of: scoliometer ATR and ST rotation measured in sitting position with trunk kyphotization, was not statistically significant, $p > 0.05$.

The number and location of detected spinal curvatures, based on: x-rays, ST examinations performed in sitting and in standing positions are shown in figure 8.

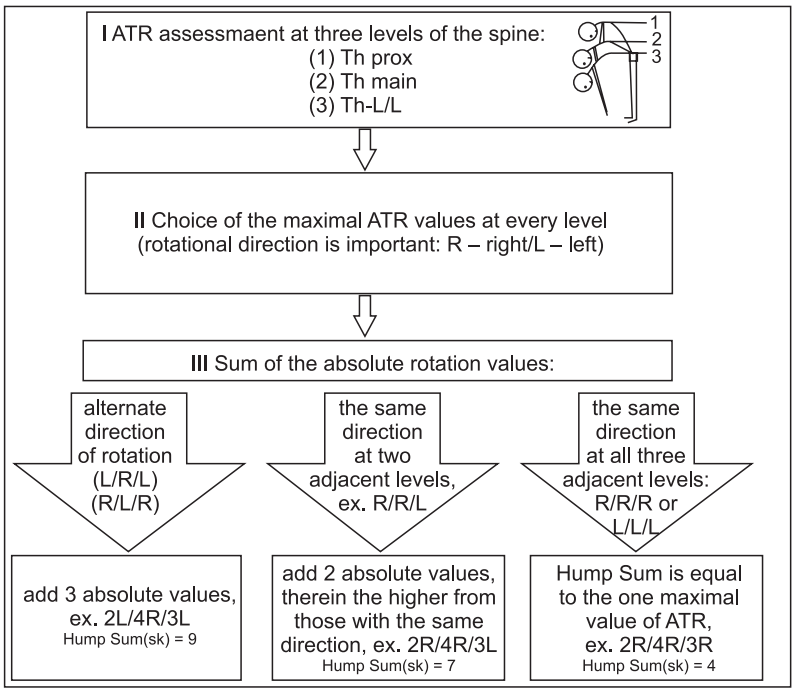


Fig. 3. Algorithm of Hump Sum parameter calculation based on ATR measured with the use of Bunnell scoliometer.

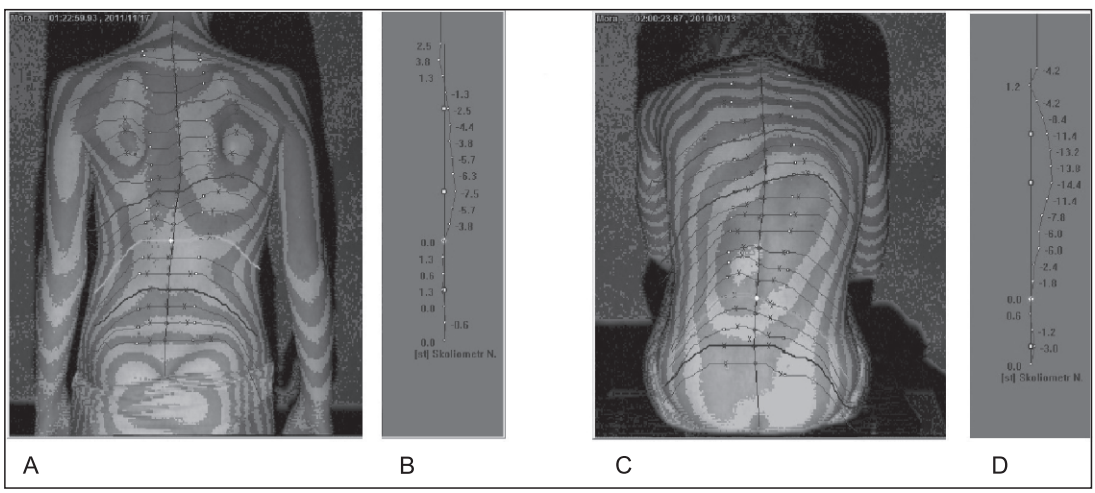


Fig. 4. Surface topography in standing position: A – patient's trunk with superimposed moire fringes, B – graph of trunk rotation in standing position. Surface topography examination in sitting position with trunk kyphotization: C – patient's trunk with superimposed moire fringes, D – graph of trunk rotation in sitting position.

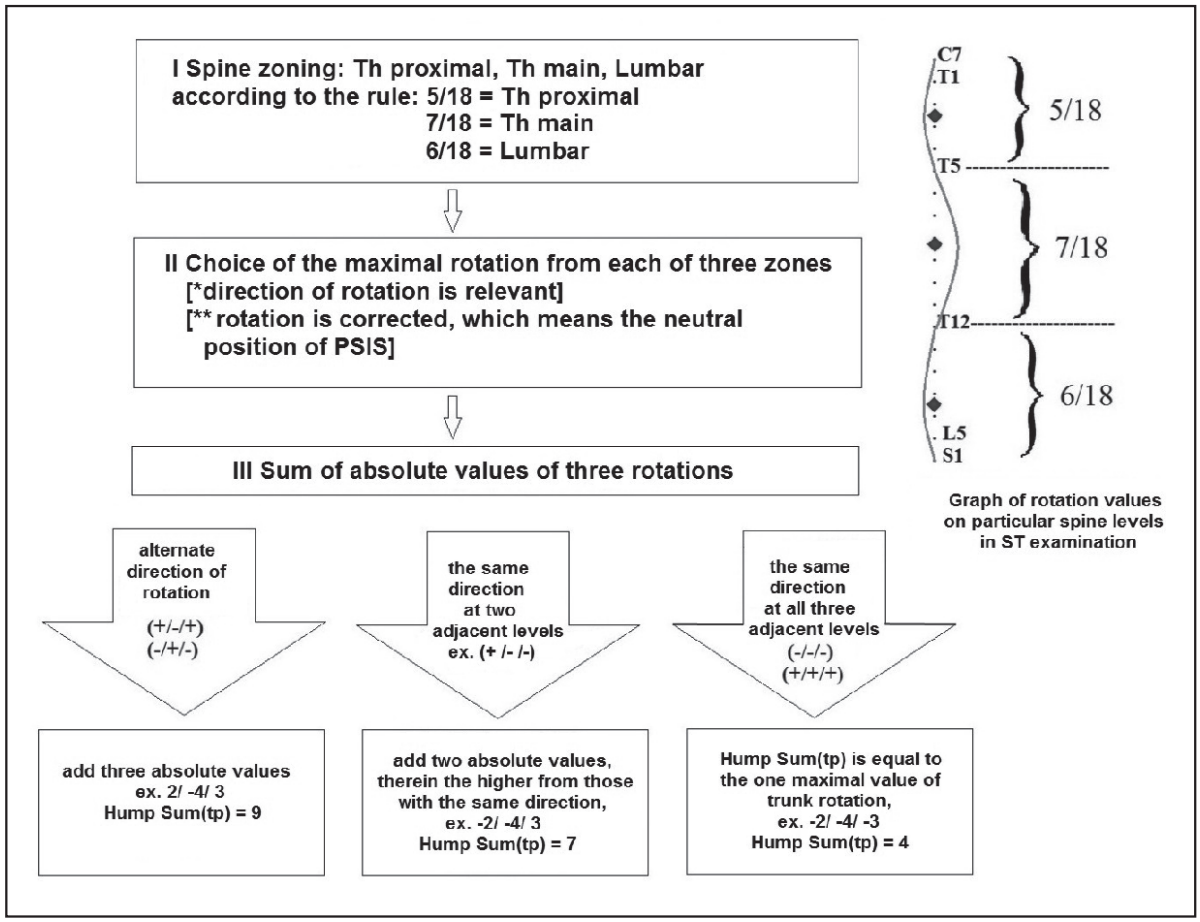


Fig. 5. Hump Sum parameter calculation algorithm based on trunk rotation measured with the use of surface topography.

Table 1. Parameters compared in: x-rays, scoliometer exam and surface topography in standing and sitting position.

Lp.	Examination	Compared parameter	Method of analysis
1.	ST standing/ST sitting	Spine length from C7 to S1	comparison of means
2.	ST standing/ST sitting	POTSI	comparison of means
3.	ST standing/ST sitting	Hump Sum(st)	comparison of means
4.	Scoliometer/ST standing	Hump Sum(sk)/Hump Sum(st)	correlation
5.	Scoliometer/ST sitting	Hump Sum(sk)/Hump Sum(st)	correlation
6.	Scoliometer/ST sitting	Mean value of trunk rotation	statistical significance
7.	X-ray/ST standing/ST sitting	Number of curvatures	statistical significance

ST – surface topography, C7 – spinal process of the seventh cervical vertebra, S1– spinal process of the first sacral bone vertebra, POTSI – Posterior Trunk Symmetry Index, Hump Sum(st) sum of trunk rotation in surface topography examination, Hump Sum(sk) – sum of trunk rotation in scoliometer examination.

Table 2. Parameters compared in TPC examination: spine length, POTSI and Hump Sum in standing and sitting position.

Parameter	ST – standing position (mean ± SD)	ST – sitting position (mean ± SD)	Statistical significance of the results difference
Spine lenght (cm)	41,5 ± 3,5	46,5 ± 3,5	$p < 0,05$
POTSI	28,9 ± 17,5	23,3 ± 13,8	$p < 0,001$
Hump Sum(tp) (°)	19,0 ± 6,6	21,3 ± 7,7	$p < 0,01$

ST – surface topography, SD – standard deviation, POTSI-Posterior Trunk Symmetry Index, Hump Sum(st) – sum of trunk rotation in surface topography examination, cm – centimeter, (°) – value in degrees.

Analysis results of five options for sitting position with trunk kyphotization regarding stability and usefulness in ST examination:

1. option – sitting position with trunk kyphotization, shoulder girdle above a pelvis, lower extremities with knee and hip joints bent at about

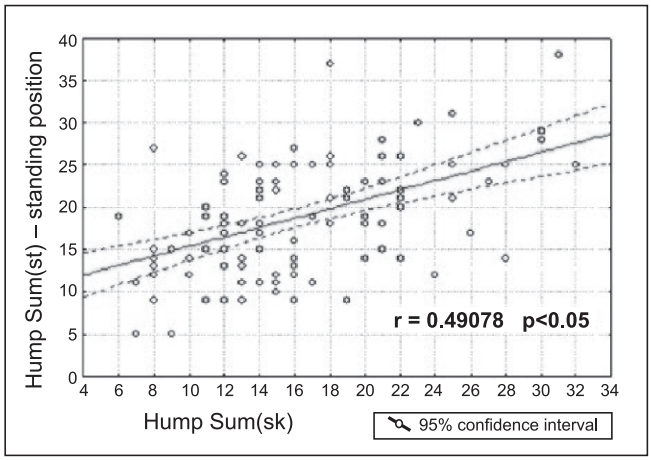


Fig. 6. Correlation of trunk rotation values in scoliometer examination and in surface topography in standing position.

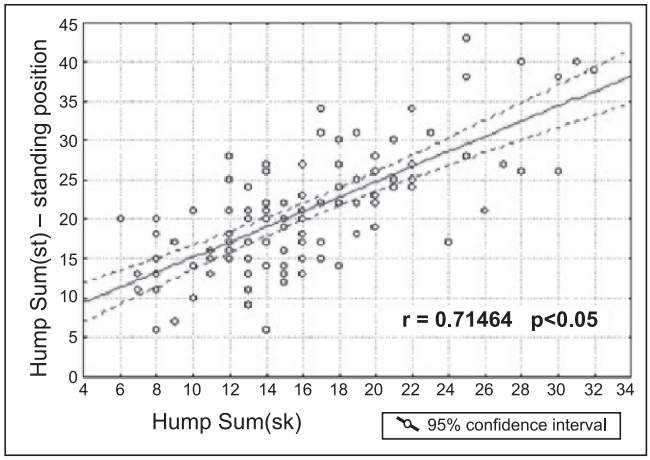


Fig. 7. Correlation of trunk rotation values in scoliometer examination and in surface topography in sitting position.

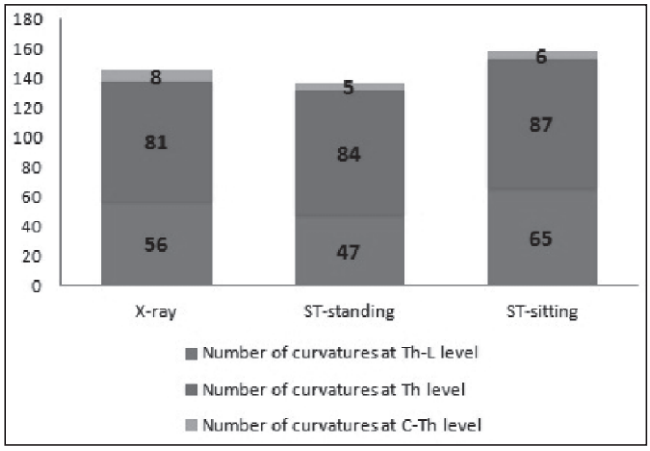


Fig. 8. Comparison of number of curvatures detected in x-ray exam and surface topography in sitting and standing position.

90°; position assessment: stable, useful for ST examination.

2. option – sitting position with trunk kyphotization, shoulder girdle above a pelvis, lower extremities with knee and hip joints bent at angle higher than 90°; position assessment: less useful than the first option because of lower stability caused by reduction of surface support.
3. option – sitting position with trunk kyphotization, shoulder girdle above a pelvis, lower extremities with knee and hip joints bent at angle lower than 90°; position assessment: less useful than the first option because of a tendency to lean forward.
4. option – sitting position with trunk kyphotization, shoulder girdle positioned backwards in relation to a pelvis, lower extremities with knee and hip joints bent at about 90°; position assessment: less useful than the first option because the examination focuses on cervico-thoracic region, where scoliosis occurrence is less frequent.
5. option – sitting position with trunk kyphotization, shoulder girdle positioned forwards in relation to a pelvis, lower extremities with knee and hip joints bent at about 90°; position assessment: less useful than the first option because the examination focuses on the lumbar region, which is too low, because the most important is detection of more frequently progressing thoracic scoliosis.

DISCUSSION

The number of curvatures detected in ST examination in both positions and in an x-ray differs slightly. It can result from the lack of cut off values serving for recognition of the curvature as a scoliosis – that is why all curvatures were taken into account. For an x-ray examination, curvatures less than 10° of Cobb angle were not taken into account.

There were more curvatures detected in ST sitting position (158 curves) than in standing one (136 curves). It means that in standing position not every curve was detected (22 curves were not detected).

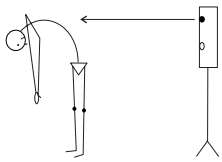
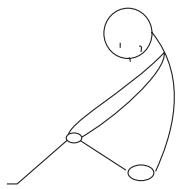
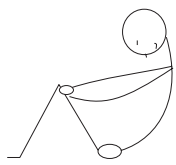
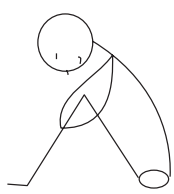
The Hump Sum(st) in sitting position was higher than in standing one. It can be explained by the fact, that there were more curves detected and higher trunk rotation values obtained in sitting position. Higher sensitivity of ST sitting position was obtained by trunk kyphotization. Similar relation is used in scoliometer ATR measurement performed in Adams test which is more sensitive in rotation detection than examination performed in standing position.

Sitting position for ST examination seems to be the only one possible to achieve by children who are not able to maintain natural and stable standing position. During the examination we noticed that some children had that problem and they were always very tense despite some changes of position. In sitting position we did not notice such difficulties.

In overweight patients, sitting position with trunk kyphotization makes it easier to notice any trunk deformity, which can be covered by excess fat in standing position.

In case of ST examination performed to detect scoliosis, it is very important to select the patient's position very carefully. The position should allow good visualization of the trunk deformity and also be stable, symmetrical, easy to perform for a child. In this study we took into consideration the following positions: (1) relaxed standing, (2) standing with forward bending of the trunk

Table 3. The validity of different body positions for the purpose of ST examination.

No.	Scheme	Position Description	Advantages	Disadvantages	Usefulness
1.		**Standing, upright, relaxed;** upper extremities along trunk, patient looks straight ahead; feet slightly separated	+ whole posture visible in functional position + easy and fast + good view of characteristic points used for trunk deformation assessment: acromions, lower angles of scapulae, waistline triangles, superior posterior iliac spines	– influence on posture of: feet deformations, lower extremities length difference, muscles contracture – swaying – less visible (than in bending) spinal processes alignment – lower visibility of trunk rotation	YES
2.		**Standing, forward bending,** separated feet, upper extremities hang, hands connected, directed between feet (as in Adams test)	+ great meaning for clinical evaluation of scoliosis +better curvatures visualization, especially rotation	– light beam is parallel to the patient's back, which gives incomplete view of patient's trunk	NO
3.		**Sitting with trunk kyphotization, lower extremities – hip and knee joints bent at approximately 90°,** upper extremities embracing knees, chin adjacent to sternum	+ easy and fast + spinal processes are well visible + focus of examination on the middle of trunk + stable + elimination of influence of asymmetric pelvis alignment	– it has not been used before – more difficult assessment of anatomic points location: the depth of waistline triangles, scapulae alignment – less visible cervical spine	YES
4.		**Sitting with trunk kyphotization – hip and knee joints bent at the angle > 90°, shoulders over pelvis,** upper extremities embracing knees, chin adjacent to sternum	+ spinal processes are well visible + focus of examination on the middle of trunk + elimination of influence of asymmetric pelvis alignment	– less stable	NO
5.		**Sitting with trunk kyphotization – hip and knee joints bent at the angle < 90°, shoulders over pelvis,** upper extremities embracing knees, chin adjacent to sternum	+ spinal processes are well visible + elimination of influence of asymmetric pelvis alignment	– tendency towards forward leaning increasing, after previous alignment of shoulders over pelvis	NO
6.		**Sitting with trunk kyphotization – hip and knee joints bent at approximately 90°, shoulders backward in relation to pelvis,** upper extremities embracing knees, chin adjacent to sternum	+ elimination of significant asymmetric pelvis alignment	– less stable – examination focused on cervico-thoracic area of back	NO
7.		**Sitting with trunk kyphotization – hip and knee joints bent at approximately 90°, shoulders forward in relation to pelvis,** upper extremities embracing knees, chin adjacent to sternum	+ elimination of significant asymmetric pelvis alignment	– examination focused on lumbar area of back	NO

(as in Adams test) and (3) sitting with trunk kyphotization – which includes four possible options (tab. 3).

Relaxed standing position

Description of the position

Erect, habitual and non-corrected standing position without shoes on a flat and hard floor. Symmetrically placed, hip-wide separated and equally loaded feet. A head placed parallel to the floor with straight directed sight. Upper extremities placed along the trunk (fig. 2B).

Assessment of the position

It is the standard position for ST exam. It allows three-dimensional assessment of the whole trunk in the antigravity position, evaluated from external occipital protuberance to the gluteal cleft. It allows the assessment of alignment of: acromions, lower angles of scapulae, posterior superior iliac spines, high and depth of waistlines.

The following factors should be taken into consideration during trunk shape analysis in the standing position:

a) the trunk rotation values are lower than in forward bending position;
b) asymmetric feet alignment or difference in lower extremities length have an impact on pelvis and spine position; its correction, if possible, prolongs the examination (fig. 9A).
c) there is natural swaying in standing position – that is why it is necessary to choose one film frame with parallel placement of pelvis in relation to the camera and reflecting the most natural patient position (fig. 9B-D).

Standing forward bending position

Description of the position

Standing, forward bending position (as in Adams test) with symmetrically, hip-wide separated feet and erect knee joints. Upper extremities loose hanging, hands connected, directed between feet.

Assessment of the position

Adams test is considered as one of the most sensitive clinical method for scoliosis detection (1). It has its limitation in ST exam, because the light beam is parallel to the patient's back, which gives incomplete view of patient's trunk. Trunk rotational assessment is possible only at one level (fig. 10).

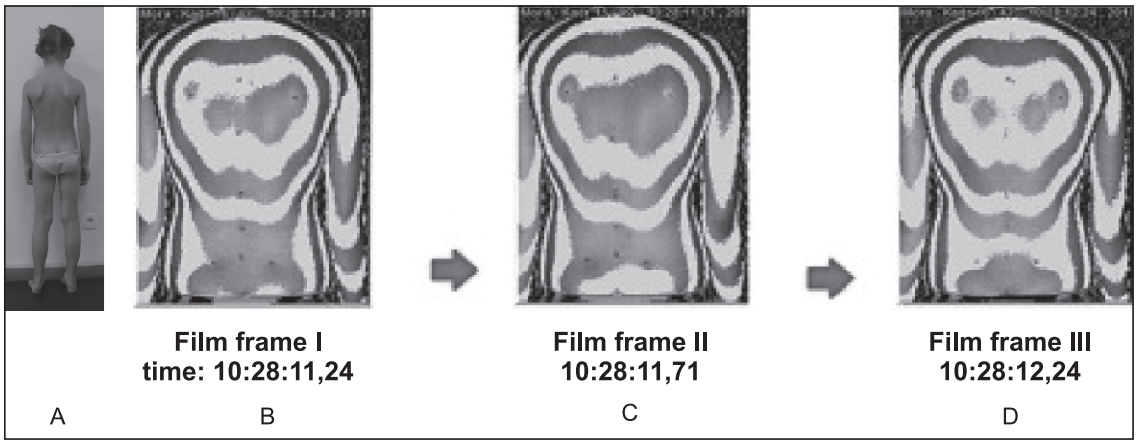


Fig. 9. Relaxed standing position: A – posterior view: bigger valgity of left foot in comparison to the left foot, causing asymmetric alignment of pelvis; B – D: view of trunk during surface topography examination with superimposed moire fringe, visible swaying of body during one second.

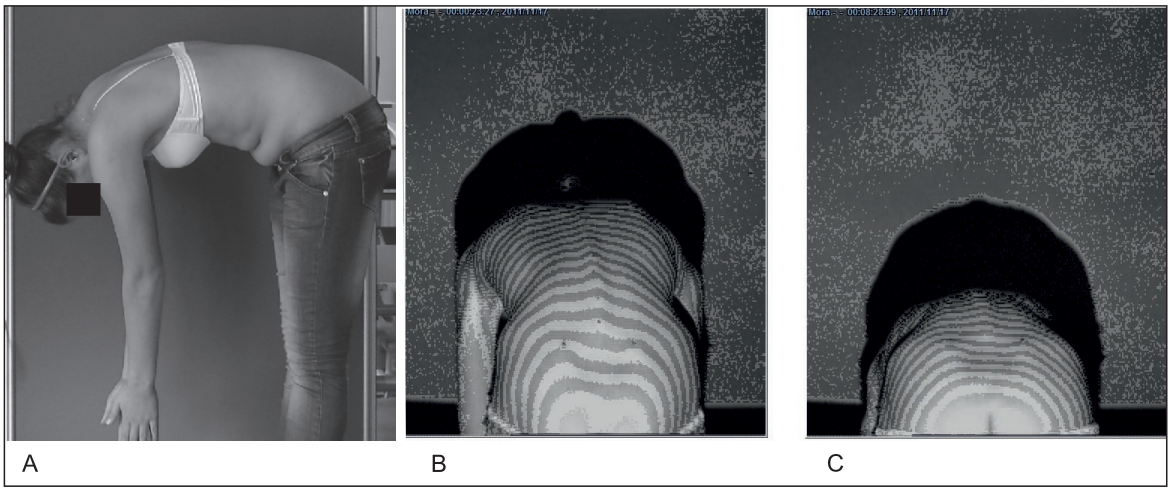


Fig. 10. Surface topography in forward bending standing position: A – lateral view, B, C – posterior view (B-slight bend, C – deepened bend).

Sitting position with trunk kyphotization

Description of the position

Sitting on the floor position with maximal trunk kyphotization. Hip and knee joints bent at approximately 90°. Shoulder girdle above a pelvis, head lowered, upper extremities embracing knees. The middle of a back should be the hindmost area, which is the nearest to the camera (fig. 11).

A B

Fig. 11. Sitting position with trunk kyphotization: A – lateral view, B – posterior view.

Assessment of the position

Sitting position is much more stable than the standing one. Ribs shape is more visible after embracing the knees by arms, which results in scapulae spreading. The sitting position includes advantages of Adams test – well visible spinal processes and trunk rotation. It is easy to perform, but instructions and help of examiner are necessary – especially in proper shoulder positioning. It eliminates the impact of lower limbs asymmetry on pelvis position. There is no need to camera positioning adjustment when all patients sit on the same level that speeds up the exam.

Disadvantage of this position is worse visibility of characteristic anatomical landmarks, like: acromions, lower angles of scapulae, posterior superior iliac spines and waistlines.

The summary of analyzed body positions for the purpose of ST examination is shown in table 3.

CONCLUSIONS

ST examination can be successfully performed in sitting position with trunk kyphotization. It is easy to do and more stable than standing one. It also eliminates the asymmetrical pelvis position influence on the trunk shape. The correlation between rotation values obtained in ST sitting position and scoliometer exam results is higher than between ST standing position and scoliometer. Trunk kyphotization allows obtaining higher sensitivity for trunk rotation values, better visualization of spinal processes and spinal curvatures.

List of abbreviations

ATR – Angle of Trunk Rotation
ST – surface topography
ST-Sit – surface topography examination in sitting position
ST-Stand – surface topography examination in standing position
POTSI – Posterior Trunk Symmetry Index
cm – centimeters
kg – kilograms
Hump Sum(sk) – Hump Sum parameter for scoliometer examination
Hump Sum(st) – Hump Sum parameter for surface topography examination
C7 – seventh cervical spinal process
S1 – first sacral spinal process

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Aaddress/adres:
*Joanna Chowańska
National Scoliosis Foundation 5 Cabot Place
Stoughton, MA 02072, USA
tel.: +1 401 309-30-62
e-mail: Joanna.Chowanska@scoliosis.org