SPINAL ROTATION METER : DEVELOPMENT AND COMPARISON OF A NEW DEVICE

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Quantification of the bending test became necessary within a large school screening for scoliosis, which started in 1983 in the central part of the Netherlands. Measurement of the angle of trunk rotation appeared to be the easiest method for the school doctors involved. Since at that time no device was commercially available, a device was developed to permit an easy and reliable angle measurement. Methodological qualities of the device in the measurement of the Cobb angle on radiographs are reported. The results of interobserver variation in measurement of the angle of trunk rotation and in the determination of the Cobb angle on radiographs using this device are compared with data from other studies reported in the literature. We did not find important differences in interobserver variation. Measurements of the Cobb angle with the new device could not be distinguished from the Cobb angle determination using conventional techniques. Therefore, we conclude that the spinal rotation meter described here is a reliable device for the measurement of scoliosis parameters.

Keywords : scoliosis ; measurement error ; external devices ; Cobb angle ; spine ; rotation.
Mots-clés : scoliose ; erreur de mesure ; dispositifs externes ; angle de Cobb ; rachis ; rotation.

INTRODUCTION

In the management of scoliosis there has always been a need for more information about progression (2, 3, 6, 11, 12). The absence of a golden standard in establishing progression of scoliosis makes it desirable to consider alternative parameters to the Cobb angle. In this context the measurement of the angle of trunk rotation (ATR) has been advocated in the literature as a predictor of progression as well as a tool in upgrading the specificity of the bending test for screening (2, 5, 15, 18, 20). In 1983 a large school screening project on scoliosis started in the central part of the Netherlands. Since it involved 30,000 children, it was mandatory to increase the specificity of the screening test (Adam's bending sign). Measurement of the ATR seemed to be sufficient for this purpose. Therefore, a spinal rotation meter (SRM) was developed and the data for its reliability in measuring the angle of trunk rotation as well as the Cobb angle are tested and compared to data from the literature.

DEVELOPMENT

In clinical practice essentially three methods are available for the determination of asymmetry : measurement of the rib hump height (RHH), measurement of the angle of trunk rotation (ATR), and photographic body shape techniques such as moiré topography (MT) (21). Rib hump measurement is a relatively demanding method because of the magnitude of the maximal asymmetry, while measuring varies in both vertical and horizontal planes ; the measurement has several phases and requires some experience. For the photographic techniques an extensive measurement set-up is required, and assessment of the

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pictures is time consuming. In contrast, measurement of the angle of trunk rotation consists only of a simple measurement of the angle of a tangent line. Previous studies showed no significant difference in the methodological characteristics of these three methods (16). Therefore, measurement of the angle of trunk rotation has certain advantages.

In 1902 Schulthess described a tool to measure the angle of trunk rotation (fig. 1) (17). Since this device is not commercially available we have developed a similar but improved Spinal Rotation Meter (SRM).

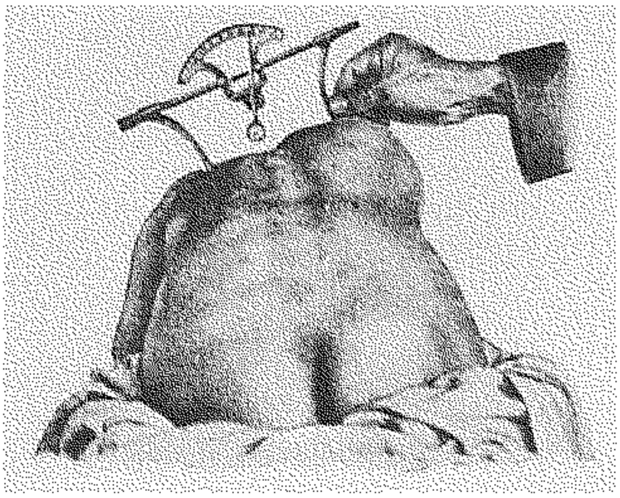

Fig. 1. — Schulthess meter.

As the study started in 1983 we were not aware of the existence of Bunnell's "scoliometer". Our first model consisted of two plexiglass plates connected to each other with a circular metal frame. In this frame a pointer directed by gravity was fixed in such a way that rotation of the device in a perpendicular direction could not influence the measurement (fig. 2). Its two wings could be folded ; the device fitted well into the pocket of a school doctor's coat. Two problems were encountered in the use of the device : the reading scale was too small and the pointer tended to oscillate. The latter problem was solved by Bunnell in 1984 by slowing down the pointer with fluid (5).

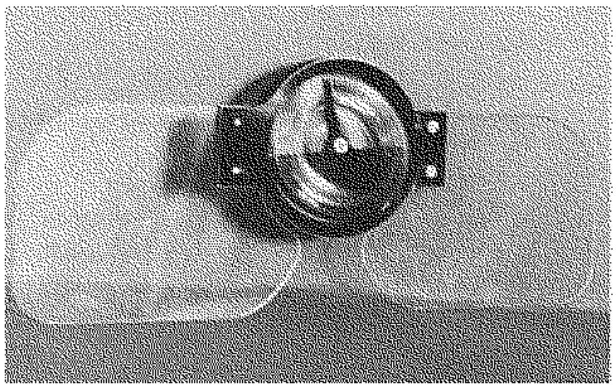

Fig. 2. — Spinal rotation meter, first model.

DESIGN AND CONSTRUCTION

The use of fluid and a pointer governed by gravity led to the idea of manufacturing a spirit level instrument. In such a tool the need for a large reading scale and a relatively slowly moving indicator can be combined. The meter that was finally developed is made of three plexiglass plates glued together. The middle plate has a large central circular hole which is half filled with oil. The circumference of the hole scaled in degrees reading zero when the instrument is horizontally held in the vertical plane. The instrument allows a rapid and easy determination of an inclination angle on the back of a forwardly inclined subject (fig. 3). It is also used to determine the Cobb angle on a vertically mounted radiograph (fig. 4). In clinical use only the maximum hump was recorded and used for comparison.

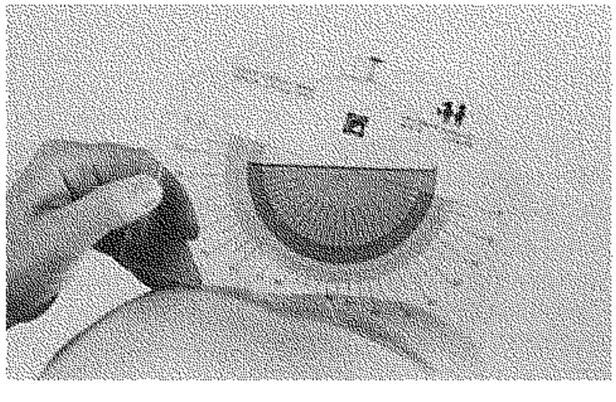

Fig. 3. — Angle of trunk rotation measurement.

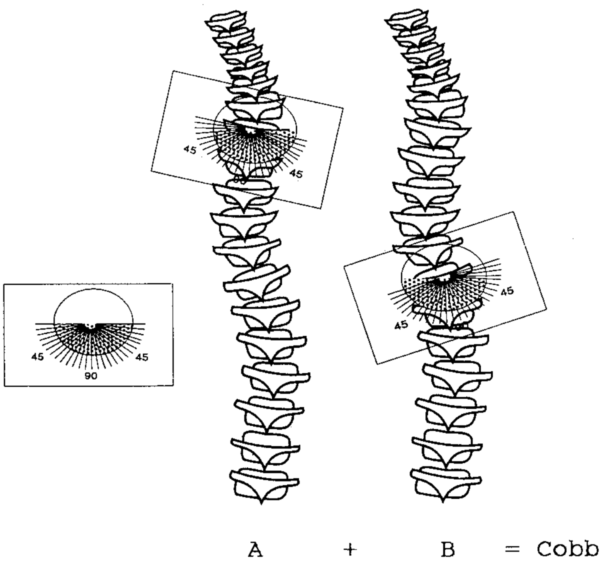

Fig. 4. — Cobb angle measurement (A + B).

The mobility of the fluid meniscus is adjustable by adding some paraffin oil*.

METHODS

The reliability of the measurement by the use of this device was tested by determination of the interobserver variation of (1) the angle of trunk rotation measurement and of (2) the Cobb angle measurement on radiographs.

The angle of external trunk rotation is measured during the bending test. The spinal rotation meter is moved distally over the back, while the central free space at the baseline is kept in the central line of the spine. The maximum inclination of a rib hump is read in whole degrees. The measurements were carried out at the same visit of the patient by two orthopedic surgeons (WK, JEHP) independently. Only the maximum rotation was recorded. The figures concerning the interobserver variation as obtained by the use of the device described here (first spirit level model) are compared to the results on interobserver variation reported by Vercauteren while measuring the rib hump height (RHH), and to the results reported by Mubarak *et al.* (13, 20). Although the rib hump height is measured in millimeters, the result of this measurement is related to the angle of trunk rotation by the shape and magnitude of a trunk asymmetry. In the absence of other data it may be of use to compare rib hump height and rotation figures. However, it should be remembered that these figures are of different orders.

The Cobb angle is measured on a vertically mounted radiograph. After determination of the two end vertebrae of the curve to be measured, both inclination angles are measured. Adding up these two angles gives the Cobb angle (22). These measurements were done by an orthopedic surgeon (JEHP) and a fellow in orthopedic surgery (MAPEH), using different SRM's (latest models). In addition, the measurements of the orthopedic surgeon were tested against the measurements of another orthopaedic surgeon (WK), who measured the Cobb angles in the original fashion as described by Cobb (3).

The results of all measurements were statistically analyzed by Student's T-test and by calculating the Spearman correlation coefficient.

SUBJECTS

Subjects who were examined were selected from the scoliosis population of our clinic (N = 38, mean age 13.8 range 9.0-16.4 years).

Radiographs which served as material for the Cobb angle determination were collected randomly from the scoliosis population of our clinic (N = 46, mean Cobb angle 13.3 ; range 0 to 37°).

RESULTS

The results of these analyses are summarized in table I. All correlations were significant, $p < 0.001$.

Mubarak *et al.* used the Bunnel scoliometer for evaluation of interobserver errors. It is the only other available study concerning interobserver variation of angle of trunk rotation measurements (13). Their standard deviations are used in the comparison together with the data reported by Vercauteren (20). The results are listed in table II.

Several studies concerning Cobb angle measurement are available and provide figures which can be compared (1, 4, 7, 9, 10, 14). Therefore values of standard deviations and, when available, correlation coefficients were used for comparison. The results are summarized in table III.

* This instrument is provided by Firma Ortomed, Zwijndrecht, The Netherlands.

Table I. — Spinal Rotation Meter Analysis

	N patients	N measurements	SD	SE	Corr
Angle of trunk rotation	38	76	2.3	0.4	.70
Cobb angle, both SRM	46	92	1.9	0.3	.98
Cobb angle, different method	46	92	2.1	0.3	.97

Note : SRM = Spinal Rotation Meter.

Table II. — External measurement reports

	N patients	N measurements	SD	Corr
Mubarak *et al.* (ATR)	22	66	4.0	NR
Vercauteren *et al.* (RHH)	1	10	1.7	NR
Spinal rotation meter (ATR)	38	76	2.3	.70

Note : NR = Not Reported.

Table III. — Cobb angle measurement

	N patients	N measurements	SD	Corr
Appelgren *et al.*	37	148	3.19	NR
Beekman and Hall	10	20	NR	.66
Carman	8	40	2.97	NR
Desmet *et al.* (intraobserver)	78	256	NR	.96
Goldberg *et al.*	30	120	2.5	.98
Morrissy *et al.*	48	192	7.2	NR
Both measurements by SRM	46	92	1.9	.98
SRM compared to classic technique	46	92	2.1	.97

Note : NR = Not Reported
SRM = Spinal Rotation Meter.

DISCUSSION

Mubarak *et al.* reported on three investigators examining 22 subjects using Bunnell's scoliometer. They found a SD of 4° in interobserver variation. The SD found in our study is of the same order. They also reported a difference in accuracy of the scoliometer when measuring below and above 15°. Their range of measurements was not reported, but the range of Cobb angles concerned was 5 to 40°. In our material only one measurement was above 15° but as reported earlier we did not note any tendency for the variation to increase while measuring more severe scoliosis (16). The inaccuracy reported is probably caused by the fact that Bunnell's scoliometer is calibrated up to 30° and the SRM has a full radius from zero to 180°. Vercauteren *et al.* reported a SD of 1.7 millimeters in measuring the rib hump height of one patient by 10 investigators. The range of measurements in his study (0-4 millimeters) is an important factor in producing such a level of agreement.

Generally these studies report differences up to 10° in measurement. The standard deviations ranged from 1.0 to 7.2°. The figure of 7.2° was found in the study of Morrissy *et al.* (14). They found a difference in accuracy of the protractor used. All the other studies reported interobserver variations of less than 5°. The standard deviation in our study while using the SRM is of the same order.

In order to judge the reliability in measuring the Cobb angle with the SRM, the observer variation between the Cobb angle measurement with the SRM and the measurement in the original manner has been compared to the other data found in the literature. The differences encountered are of the same order and at the lower limit of all interobserver variations. This leads to the conclusion that this new SRM is a reliable device to assess the Cobb angle on radiographs. Apparently, the rapidity and ease of the Cobb angle measurement using this device do not influence in any way the quality of measurement.

CONCLUSION

The interobserver variations concerning measurement of the angle of trunk rotation reported in the literature and in our studies using the spinal rotation meter are all of the same order. In the observer variation of Cobb angle determination no difference can be noted between the use of the spinal rotation meter and the original method of measurement. Therefore the newly developed spinal rotation meter appears as a valuable device for measuring the angle of trunk rotation as well as for the determination of the Cobb angle. It is easily constructed and simple to use.

Note

We regret to inform the reader the loss of Dr. W. Keessen, December 1993.

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REFERENCES

1. Appelgren G., Udén A., Willner S., Montgomery F. Assessment of intraobserver, interobserver and PA-radiograph reliability in measurement of scoliosis. Amsterdam, Proceedings meeting SRS, 1989, 330-331.
2. Ashworth M. A., Ersil A. K. The measurement of rib hump inclination — A potential aid in scoliosis screening. Scol. Res. Soc., 1981, 5, 33-34.
3. Barsanti C. M., Bari A. de, Covino B. M. The torsion meter : a critical review. J. Pediatr. Orthop., 1990, 10, 527-531.
4. Beekman M. S., Hall V. Variability of scoliosis measurement from spinal roentgenograms. Phys. Ther., 1979, 6, 764-765.
5. Bunnell W. P. An objective criterion for scoliosis screening. J. Bone Joint Surg., 1984, 66-A, 1381-1387.
6. Burwell G. The British decision and subsequent events. Spine, 1988, 13, 1192-1194.
7. Carman D. L., Browne R. H., Birch J. G. Measurement of scoliosis and kyphosis radiographs. J. Bone Joint Surg., 1990, 72-A, 328-333.
8. Cobb J. R. Outline for the study of scoliosis. Instructional course lectures. The American Academy of Orthopaedic Surgeons, Ann Arbor, J. W. Edwards, 1948, 5, 261-275.
9. Desmet A., Goin J. E., Asher M. A., Scheuch H. G. A clinical study of the differences between the scoliotic angles measured on posteroanterior and anteroposterior radiographs. J. Bone Joint Surg., 1982, 64-A, 489.
10. Goldberg M. S., Poitras B., Mayo N. E., Labelle H., Bourassa O., Cloutier R. Observer variation in assessing spinal curvature and skeletal development in adolescent idiopathic scoliosis. Spine, 1988, 13, 1371-1377.
11. Kindsfater *et al.* Denver, USA. Platelet calmodulin levels in adolescent idiopathic scoliosis ; Prediction of curve progression and severity. J. Pediatr. Orthop., 1994, 14, 3, 395 (abstract).
12. Kostuik J. P. Current concepts review. Operative treatment of idiopathic scoliosis. J. Bone Joint Surg., 1990, 72-A, 1108-1113.
13. Mubarak S. J., Wyatt M. P., Leach J. Evaluation of the intra-examiner and inter-examiner reliability of the scoliometer in measuring trunk rotation. Proceedings of the Scoliosis Research Society, 19th annual meeting, September 19-22, 1984, Orlando, Florida, 66.
14. Morrissy R. T., Goldsmith G. S., Hall E. C., Kehl D., Cowie G. H. Measurement of the Cobb angle on radiographs of patients who have scoliosis. J. Bone Joint Surg., 1990, 72-A, 320-327.
15. Ponte A. Prognostic evaluation of vertebral rotation in small idiopathic curves. Proceedings S.R.S., Denver, 1982, 20, 46-47.
16. Pruijs J. E. H., Keessen W., Meer R. van der, Wieringen J. C. van, Hageman M. A. P. E. School screening for scoliosis : Methodologic considerations Part 1 : external measurements. Spine, 1992, 17, 431-436.
17. Schulthess W. Über die Lehre des Zusammenhanges der physiologischen Torsion der Wirbelsäule mit lateraler Biegung und ihre Beziehungen zur Skoliose. Z. Orthop., 1902, 10, 455-494.
18. Schumpe G., Hofmann P., Rössler H. Problematik der Verlaufskontrolle bei Skoliosepatienten. Z. Orthop., 1984, 122, 243-254.

19. Torell G., Nordwall A., Nachemson A. The changing pattern of scoliosis treatment due to effective screening. J. Bone Joint Surg., 1981, 63-A, 337-341.
20. Vercauteren M., Beneden M. van, Verplaetse R., Croene P., Uyttendaele D., Verdonk R. Trunk asymmetries in a Belgian school population. Spine, 1982, 7, 555-562.
21. Willner S. Moiré topography for the diagnosis and documentation of scoliosis. Acta Orthop. Scand., 1979, 50, 295-302.
22. Wittle M. W., Evans M. Instrument for measuring the Cobb angle in scoliosis. Lancet, 1979, 414.

SAMENVATTING

J. E. H. PRUIJS, M. A. P. E. HAGEMAN, W. KEESSEN, R. VAN DER MEER, J. C. VAN WIERINGEN. Romp rotatie meters : ontwikkeling van een nieuw instrument.

In dit artikel wordt de ontwikkeling van de „spinal rotation" meter beschreven. Deze techniek werd al in 1902 beschreven, maar was in onbruik geraakt. Een meetinstrument was dan ook niet verkrijgbaar. Gezien de adviezen in de recente literatuur om de romp rotatie te meten, werd een vergelijkbaar instrument ontworpen. Na enkele prototypen werd een praktische meter ontwikkeld. De meetfout van het apparaat werd onderzocht voor zowel de romp rotatie meting als voor het bepalen van de Cobbse hoek. Hiervoor werden data van eerdere studies nader geanalyseerd. De resultaten werden vergeleken met bevindingen uit de literatuur. Geconcludeerd wordt dat de meter een betrouwbaar stuk gereedschap is, waar zowel scoliose mee „ontdekt" als vervolgd kan worden. Ook het gebruik van de meter voor het bepalen van de Cobbse hoek, lijkt even betrouwbaar als de originele methode.

RÉSUMÉ

J. E. H. PRUIJS, M. A. P. E. HAGEMAN, W. KEESSEN, R. VAN DER MEER, J. C. VAN WIERINGEN. Mesure de la rotation du rachis. Présentation d'un nouvel instrument.

Au cours d'un vaste projet de dépistage scolaire de la scoliose, commencé en 1983 dans la région centrale des Pays-Bas, une quantification de la gibbosité mesurée en flexion du tronc s'est révélée indispensable. La mesure de l'angle de rotation du tronc paraît être le test le plus simple à exécuter par les médecins scolaires. A cette époque, aucun instrument n'était commercialement disponible. Les auteurs décrivent un nouvel instrument de mesure de la gibbosité. Description des qualités méthodologiques de l'instrument de mesure de l'angle de rotation du tronc ainsi que de l'angle de Cobb sur les radiographies. Les résultats concernant la variation des mesures de ces deux angles par le nouvel instrument, entre les différents observateurs, sont comparés avec les données d'autres études de la littérature. Nous n'avons pas constaté de différence importante dans les variations entre les observateurs. La mesure de l'angle de Cobb avec le nouvel instrument donna des résultats semblables à ceux obtenus par la technique conventionnelle. Les auteurs concluent que l'instrument de mesure de la rotation du rachis décrit dans cet article, est fiable pour l'évaluation des différents paramètres.