

Pilot study on using formetric scanning method to investigate spinal deformity of Vietnamese students

Vo Quoc Khanh¹, Nguyen Thao Hoang¹, Nguyen Le Thanh Truc¹, Nguyen Thi Le Quyen¹,
Nguyen The Thuong², Tran Anh Tu¹, Huynh Quang Linh^{1,*}



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ABSTRACT

The increasing trend of working time and pressure on students, especially passive posture due to using computers in the learning process with inadequate attention to health has made spinal abnormal symptoms more and more common in the world. In particular, spinal deformity is one of the reasons affecting the normal development of adolescents, causing many circulatory and respiratory diseases and leading to psychological effects as well. Early detection of spinal deformities is thus one of the important tasks in routine scoliosis screening at secondary school in many countries, but not yet in Vietnam. The purpose of this study was to test the use of the DIERS formetric 4D device to conduct a pilot study on the spinal deformity of a group of students to investigate the possibility of using this method for widespread deployment in the future of scoliosis screening program. This is a new spine measurement method that does not use ionizing radiation, gives multi-parameter results, and is suitable for periodic scoliosis screening for all ages. Experimental measurements were performed on a group of 40 students consisting of 26 males and 14 females. The results showed that most of the students had abnormal expressions such as hunchback, and scoliosis. 18 out of 40 samples showed pelvic dislocation. The above cases can be caused by prolonged sitting time, a lack of physical exercise, and a wrong sitting posture. Abnormal cases in women have some common features of living habits. The results of the mentioned pilot study allow us to determine the necessary factors to use the DIERS method in proposing the implementation of a mass screening program for spinal deformities, especially in the national school medicine program.

Key words: DIERS formetric 4D, scoliosis, routine scoliosis screening

¹Faculty of Applied Science, Ho Chi Minh City University of Technology, VNU-HCM, Vietnam

²Institute of Biomedical Physics, Ho Chi Minh City, Vietnam

Correspondence

Huynh Quang Linh, Faculty of Applied Science, Ho Chi Minh City University of Technology, VNU-HCM, Vietnam

Email: huynhqlinh@hcmut.edu.vn

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INTRODUCTION

According to the current investigation of spinal abnormalities, adolescent idiopathic scoliosis is a common disease with an overall prevalence of 0.47–5.2 % of the population¹. Many countries around the world have performed extensive spine screening for adolescents for many years ago, while in Vietnam it has only tested about 10 years ago and on a very small scale of about a hundred students² and the rate of scoliosis was about 18.9%. With the rate of scoliosis much higher than in other countries, Vietnam needs a spine screening program for students, thereby taking measures to protect the spine for the next generation future.

The diagnosis of scoliosis is mainly based on clinical signs such as the appearance of curves in the spine, shoulder and pelvic asymmetry, bipedal disparity or Cobb angle measured in radiographs. Scoliosis is a term used to describe the curvature of the spine to the side of the body axis and curvature of the vertebral bodies along the axis of the transverse plane, as distinct from kyphosis or lordosis is the deformation of

the spine along the anteroposterior axis. Scoliosis reduces or loses the ability to work and be independent in daily life, and is the cause of many medical conditions such as cardiovascular, respiratory, and motor system diseases if not detected early, treatment is correct and timely. Therefore, early detection of scoliosis will help prevent dangerous complications later.

The diagnosis of scoliosis is mainly based on clinical signs such as the appearance of curves in the spine, shoulder and pelvic asymmetry, bipedal disparity or Cobb angle measured in radiographs, and rotation of the spine or the vertebral body measured with a scoliometer. However, X-rays will be harmful to health, and measuring on a scoliometer will give results that are highly dependent on the measurer, reducing the accuracy of the assessment, and leading to incorrect treatment. Therefore, it is possible to use some other methods such as 3D ultrasound imaging, Moiré surface topography, formetric optical method, etc.³ to screen effectively and without harm to health. To prepare for the implementation of mass measurement of idiopathic scoliosis for Vietnamese adolescents using the DIERS FORMETRIC 4D device, the research

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group performed the pilot experiment of study on student spinal deformity by formetric scanning method, which was carried out with the following objectives:

1. Survey the characteristics and assess the status of the spine of selected students.
2. First evaluation of the relation between risk factors in school and grades of scoliosis.

METHODOLOGY

The study investigated 40 subjects, which are student volunteers at the University of Technology – VNU HCM aged from 15 to 22 years old (Table 1). The exclusion criteria include spinal cord injury, spine surgery, tattoo on the back surface, scoliosis caused by Marfan syndrome, Arnold Chiari syndrome, vertebral body malformation, neuromuscular disease, and low leg deformity. The experiment was conducted at the MTT REHA Clinic from REHASO Company, Ho Chi Minh City using DIERS FORMETRIC 4D equipment.

DIERS FORMETRIC 4D system (DIERS International GmbH) is optical scanning equipment based on Video-Raster-Stereography method. There is commercial equipment (CE marked and FDA approved) for rapid static and dynamic (functional) optical measurements of the back and spine. Accordingly, the system consists of a light projector that projects a line grid on the back of the patient which is recorded by an imaging camera. Recording data are used for resurfacing and analysis of the back surface using the software based on photogrammetry method, which analyzes the line curvature and generates a three-dimensional model of the surface, and derives the corresponding form of the spine. In opposition to x-ray, the DIERS formetric provides comprehensive information about the whole body statics and posture in only one measuring process, e.g. spine curvature (lateral and frontal), vertebral rotation, and pelvic position. The procedure is radiation-free, non-invasive, and high-resolution. The system can provide a variety of clinical parameters for analysis of the body static state, standing posture, scoliosis, and all forms of spinal deformities that can be visualized. The mentioned operational procedure is illustrated in Figure 1. The system consists of an operating unit, a lifting column, a stripe projector, and a camera that occupies a space of approximately $3 \times 1.5 \times 2.5$ m including the required distance from the scanned subject to the device. The camera used has a maximum possible frame rate of 50 Hz, a CMOS sensor with an image resolution of 1280 x 1024 pixels, and a pixel size of 5.20 μm . The basic components of the system include a black velvet background which is recommended to be

placed in front of the subject to reduce reflections and enhance subject and background contrast. Diers system helps detect anatomical landmarks through a 3D computer model of the spine based on surface curvature estimation and dorsal reconstruction.

For the mentioned study, the default mode for capturing the desired subject position was used with the following parameters: time - 6s, number of recorded images - 12, recording frequency - 2 fps. The result parameters of the spine are average values calculated from obtained data and a selected image will be displayed in the results section. The advantage is that it can eliminate distorting factors such as breathing and small movements. The disadvantage may be the long recording time which can affect the patient's stillness. Experimental data were processed using IBM SPSS Statistics 26

thoraco-lumbar), lordotic angle ITL-ILS dimple software for mean analysis.

The result evaluation was performed based on the following spinal characteristic parameters: coronal imbalance VP-DM (vertebra prominens - midpoint between lumbar dimples), pelvic obliquity, pelvic torsion DL-DR (left lumbar - right lumbar dimple), vertebral rotation, apical deviation VP-DM, kyphotic angle ICT-ITL (inflection point cervical-thoracic - inflection point thoraco-lumbar), lordotic angle ITL-ILS (inflection point thoraco-lumbar - inflectional point lumbo-sacral) shown in Figure 2.

RESULTS AND DISCUSSION

Spine parameters considered to evaluate the spine based on studies by Harzmann⁵ were shown in Table 2.

There was found that the average values of some characteristics were different from normal values, especially as follows:

- Spine characteristics: the coronal imbalance VP-DM values of 45% of cases with the maximum value of 26mm are higher than the normal value; the vertebral rotation values of 7.5% of cases with the maximum value of 9° are higher than the normal value; the apical deviation VP-DM values of 42.5% of cases are higher than the normal value, with the maximum deviation of 13mm; the kyphotic angle ICT-ITL values of 20% of cases are higher than the normal value, and 7.5% of cases lower than the normal value; the lordotic angle ITL-ILS values of 52.5% of cases are higher than the normal value, and 2.5% of cases lower than the normal value; no remarkable considerations with the kyphotic angle and lordotic angle parameters in comparison with corresponding normal values.

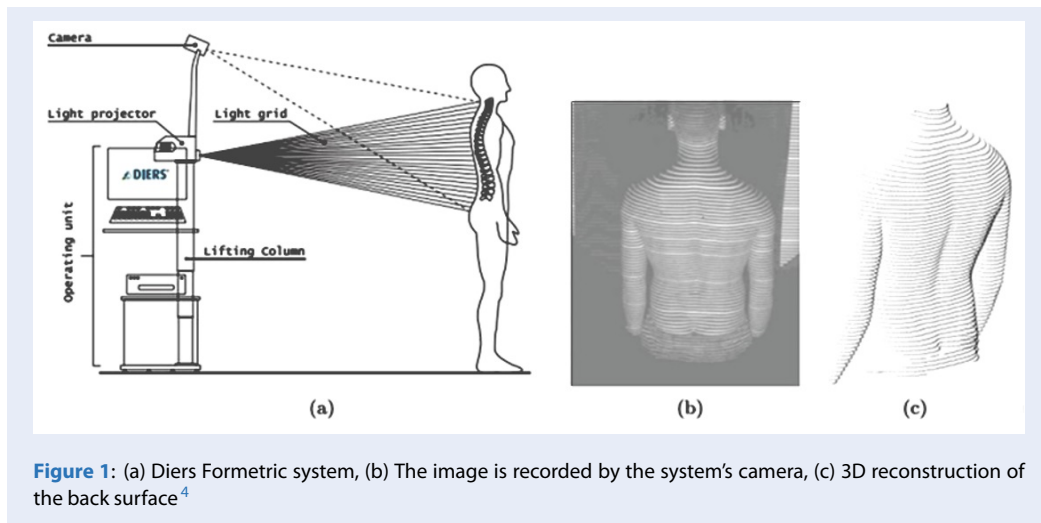


Figure 1: (a) Diers Formetric system, (b) The image is recorded by the system's camera, (c) 3D reconstruction of the back surface⁴

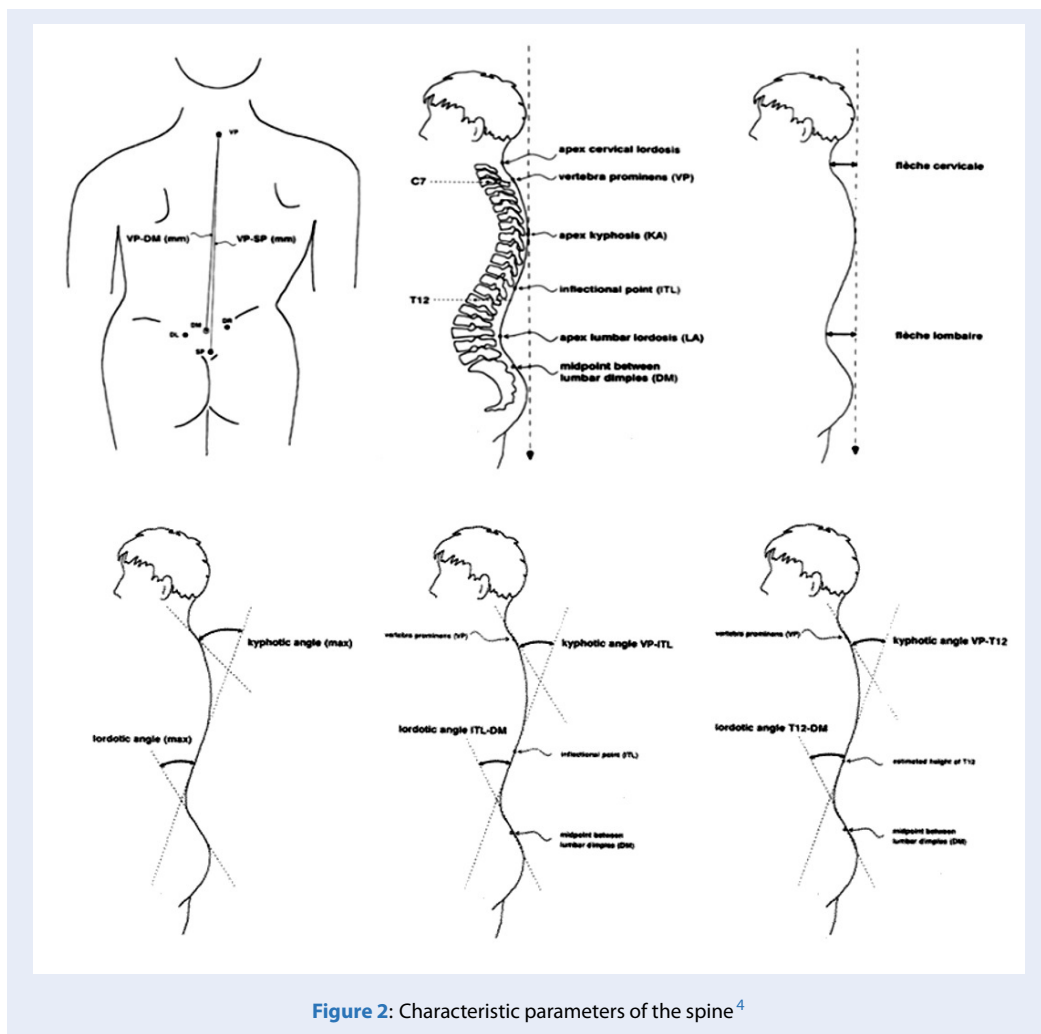


Figure 2: Characteristic parameters of the spine⁴

Table 1: Some information about the group participating in the survey experiment

	Male (N=26)		Female (N=14)		Total (N=40)	
	Mean	SD	Mean	SD	Mean	SD
Age	20.73	1.73	19.79	2.46	20.40	2.04

- Pelvic characteristics: the pelvic obliquity values of 45% of cases are higher than the normal value, with a maximum deviation of 11mm; the pelvic torsion DL-DR values of 40% of cases are higher than the normal value, with the maximum value 6°. The overall tendency is that scoliosis leads to pelvic obliquity distortion and vice versa. Pelvic obliquity is one of the causative agents of functional scoliosis, which is a type of scoliosis that is not too severe and is easier to improve than structural scoliosis. This condition can also be caused by the structural curvature of the spine affecting posture, leading to pelvic obliquity.

For male students, there are 34.6% of cases with coronal imbalance VP-DM, 26.9% of cases with pelvic obliquity, 38.5% of cases with pelvic torsion DL-DR, 3.8% of cases with vertebral rotation, and 34.6% of cases with apical deviation VP-DM are higher than corresponding normal values; 26.9% of cases with kyphotic angle ICT-ITL and 61.5% of cases with lordotic angle ITL-ILS are out of the normal range. For female students, there are 64.3% of cases with coronal imbalance VP-DM, 78.6 % of cases with pelvic obliquity, 42.9% of cases with pelvic torsion DL-DR, 14.3% of cases with vertebral rotation, 57.1% of cases with apical deviation VP-DM are higher than the normal value; 28.6% of cases with kyphotic angle ICT-ITL and 42.9% of cases with lordotic angle ITL-ILS are out of the normal range. The percentage difference is thus higher for women than for men.

The purpose of this study is to build up a proper procedure for spine screening programs for selected populations using the DIERS formetric method and equipment.

The process of designing and implementing mentioned survey measurement of student spine deformity achieved the following results:

- Spinal characteristic parameters are calculated from the grid image taken on the back of the subject using reliable software that has been internationally approved. This is a non-invasive, fast, radiation-free method, convenient for people of all ages. The back surface image acquisition can be done using mobile devices add-on designed in combination with IoT transmission to transfer data to a centralized processing server. The mentioned solution is especially

appropriate for the implementation of mass spinal screening program for large populations.

- The data and results of the experiment show good repeatability, high reliability, providing many parameters for complex assessment, not only of the spinal structure but also characteristics of the spine-pelvic system, helping to improve the epidemiological reliability of such healthcare monitoring programs. However, in order to have a proper assessment for Vietnamese people, additional epidemiological studies are needed to determine standard parameters appropriate for Vietnamese people. The DIERS formetric method is remarkably suitable for conducting these epidemiological studies.

- Multi-parameter scoliosis assessment and screening by DIERS formetric method open up possibilities for IoT applications, machine learning data processing techniques to design automated assessment systems to support spinal screening program for the population as well as professional diagnoses for the treatment of related diseases.

- The experimental study of student spinal parameters measurement by DIERS formetric method provides relevant information, not only for expertise but also for cost and feasibility to propose a national program for scoliosis screening belong the school healthcare program, which is an essential issue related to the physical development of national future generations. The mentioned results from the pilot study compared with individual questionnaires asking about information such as gender, age, BMI, sitting time, sitting posture, type of backpack, frequency of exercise, etc. showed that the factors such as sitting time, sitting posture, type of backpack, and frequency of exercise have closed relations with mentioned abnormalities of characteristics. But they were not the main purpose of this study; they need to be proven as the considerable cause of spinal deformity by more sophisticated studies with a larger sample size and proper involvement of medical professionals.

In general, most of the subjects participating in the survey showed signs of idiopathic scoliosis. Studies and surveys on scoliosis and influencing factors⁶⁻⁹ show the need for appropriate solutions in schools such as furniture, lighting, educational programs at schools, teaching children to maintain correct body

Table 2: Spine parameters of survey subjects calculated from measured data⁵

No.	Characteristic parameters of the spine	Normal value according to Harzmann (2000)	Average value of female		Average value of male		Average value	
			Mean	SD	Mean	SD	Mean	SD
1	Coronal Imbalance VP-DM (mm)	0 - 7	11.36	7.33	8.15	6.25	9.28	6.74
2	Pelvic Obliquity (mm)	0 - 4	6.50	3.17	3.38	2.90	4.48	3.31
3	Pelvic Torsion DL-DR (°)	0 - 2	2.00	1.88	2.27	1.59	2.18	1.68
4	Vertebral Rotation (rms) (°)	0 - 5	3.50	2.44	2.85	1.38	3.08	1.82
5	Apical Deviation VP-DM (rms) (mm)	0 - 5	7.00	3.72	4.88	2.41	5.63	3.06
6	Kyphotic Angle ICT-ITL (max) (°)	42 - 55	46.64	6.17	45.65	6.56	46	6.36
7	Lordotic Angle ITL-ILS (max) (°)	33 - 47	35.07	10.45	29.38	8.13	31.38	9.29

posture, justifying the weight school bag that students have to carry when they go to school everyday, and creating conditions for children to be active in sports and physical training. Besides, nutrition is an important factor for adolescent development indeed. Since then, it has been found that early screening for spinal diseases is very important for a healthy lifestyle, avoiding dangerous later complications of the musculoskeletal system.

CONCLUSION

Mentioned pilot study shows that the method of spinal monitoring using the DIERS formetric method which reconstructs the spine shape and the entire dorsal surface, can provide relevant and reliable parameters of the spine and the pelvic, and based on that professionals can diagnose early abnormalities to be properly regulated. This is an effective and fast method to evaluate the condition of the spine without radiation harm, that can be implemented for mass spinal monitoring with the use of IoT facilities. The reliability of the method has been verified worldwide and can be used widely as X-ray today.

Since risk factors can be shown to be associated with postural changes, adolescent habits need more attention at home and school. Regular evaluation of the spine is very important because it is possible to intervene early to treat, not to make the deformity too severe. Health and education professionals need to

organize scoliosis screenings for students and guide measures to reduce the risk of scoliosis.

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LIST OF ABBREVIATIONS

- FDA Food and Drug Administration
- CE European Conformity marking
- VP-DM vertebra prominens - midpoint between lumbar dimples
- DL-DR left lumbar - right lumbar dimple
- ICT-ITL inflection point cervical-thoracic - inflection point thoraco-lumbar
- ITL-ILS inflection point thoraco-lumbar - inflectional point lumbo-sacral
- BMI Body mass index

CONFLICT OF INTERESTS

The authors declare no competing financial interest.

AUTHOR’S CONTRIBUTION

Vo Quoc Khanh, Nguyen Thao Hoang, Nguyen Le Thanh Truc and Nguyen Thi Le Quyen conducted experiments and measurements; Nguyen The Thuong, Tran Anh Tu analyzed the results; Huynh Quang Linh and Nguyen The Thuong wrote the paper.

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Võ Quốc Khánh¹, Nguyễn Thảo Hoàng¹, Nguyễn Lê Thanh Trúc¹, Nguyễn Thị Lệ Quyên¹, Nguyễn Thế Thường², Trần Anh Tú¹, Huỳnh Quang Linh^{1,*}



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¹Khoa Khoa học ứng dụng, Đại học Bách Khoa, ĐHQG-HCM, Việt Nam

²Viện Vật lý Y sinh học, thành phố Hồ Chí Minh, Việt Nam

Liên hệ

Huỳnh Quang Linh, Khoa Khoa học ứng dụng, Đại học Bách Khoa, ĐHQG-HCM, Việt Nam

Email: huynhqqlinh@hcmut.edu.vn

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TÓM TẮT

Xu hướng gia tăng thời gian làm việc và áp lực trong quá trình học tập, đặc biệt tư thế thụ động khi sử dụng máy tính của học sinh sinh viên cùng với sự quan tâm không đúng mức đến sức khỏe đã khiến các triệu chứng bất thường về cột sống ngày càng phổ biến nói chung trên thế giới. Trong đó, sự biến dạng cột sống là một trong những nguyên nhân ảnh hưởng đến sự phát triển khỏe mạnh của trẻ vị thành niên, gây ra nhiều bệnh lý về tuần hoàn, hô hấp và dẫn đến cả những ảnh hưởng đến tâm lý. Do đó, phát hiện sớm các dấu hiệu bất thường của cột sống là một trong những nhiệm vụ quan trọng trong chương trình tầm soát vẹo cột sống định kỳ ở cấp giáo dục phổ thông ở nhiều nước, nhưng ở Việt Nam thì chưa. Mục đích của nghiên cứu này là thử nghiệm sử dụng thiết bị DIERS formetric 4D đo thực trạng biến dạng cột sống ở sinh viên nhằm khảo sát khả năng sử dụng đại trà phương pháp quang học hình dạng trong chương trình tầm soát bệnh vẹo cột sống đại trà. Đây là phương pháp đo cột sống mới không sử dụng bức xạ ion hóa, cho kết quả đa thông số, phù hợp để tầm soát vẹo cột sống định kỳ cho mọi lứa tuổi. Chương trình đo thí điểm được thực hiện trên một nhóm 40 sinh viên gồm 26 nam và 14 nữ. Kết quả cho thấy, hầu hết sinh viên đều có biểu hiện bất thường như gù, vẹo cột sống. 18 trong số 40 mẫu cho thấy bị trật khớp xương chậu. Các trường hợp trên có thể do ngồi lâu, lười vận động, ngồi sai tư thế. Những trường hợp bất thường ở phụ nữ có một số đặc điểm chung về thói quen sinh hoạt. Kết quả thử nghiệm cho phép xác định những yếu tố cần thiết để triển khai sử dụng phương pháp DIERS trong việc để xuất thực hiện chương trình tầm soát các biến dạng cột sống đại trà, đặc biệt trong chương trình y học đường quốc gia.

Từ khoá: phương pháp quang học hình dạng DIERS 4D, chứng vẹo cột sống, chương trình tầm soát vẹo cột sống

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