行政院國家科學委員會補助專題研究計畫成果報告

※※※※※※※※※※※※※※※※※※※※※※※※※
※　　　　　　　　　　　　　　　　　　　　　　　　※
※　脊髓損傷患者輪椅坐姿擺位系統的功能探究(2/2)　※
※　　　　　　　　　　　　　　　　　　　　　　　　※
※　　　　　　　　　　　　　　　　　　　　　　　　※
※※※※※※※※※※※※※※※※※※※※※※※※※

計畫類別：■個別型計畫　　□整合型計畫

計畫編號：NSC92－2314－B－002－084－

執行期間：92 年 08 月 01 日至 93 年 7 月 31 日

計畫主持人：毛慧芬

共同主持人：呂東武、黃小玲

本成果報告包括以下應繳交之附件：

□赴國外出差或研習心得報告一份

□赴大陸地區出差或研習心得報告一份

□出席國際學術會議心得報告及發表之論文各一份

□國際合作研究計畫國外研究報告書一份

執行單位： 台大職能治療學系

中　華　民　國　　93　年　10　月　12　日

行政院國家科學委員會專題研究計畫成果報告

計畫編號：NSC92－2314－B－002－084－
執行期限：92 年 8 月 1 日至 93 年 7 月 31 日

主持人：毛慧芬　執行機構及單位名稱：台大職能治療學系
共同主持人：呂東武(台大醫學工程研究所)，黃小玲(台大職能治療學系)
計畫參與人員：廖漢文(台大醫院影像醫學部)，林銘川、王顏和(台大醫院復健部)

中文摘要

背景：臨床上特殊擺位系統廣泛用來改善脊髓損傷個案的坐姿，但軀幹側支撐對脊柱側彎及臀部壓力的影響，卻少有相關文獻之驗證。

方法:共有 8 位脊柱側彎的男性脊髓損傷個案參與本研究。受試者坐於實驗用椅上，在有/無軀幹側支撐兩種情況下，分別量測脊柱及骨盆的位置與形狀。首先照射 X 光，然後三維脊柱骨盆曲線及臀部壓力利用動作分析系統 (Vicon 512, Oxford Metrics, U. K.) 及壓力量測系統 (Tekscan Advanced Clinsear, U. S. A.) 同步測量。脊柱側彎的嚴重度分別在 X 光影像上用科布角度 (Cobb angles)，脊突角度 (spinous process angles) 及側彎指數 (scoliotic index) 來表示。利用*配對-t* 檢定來比較上述 X 光影像取得之三種角度及由三維立體脊柱骨盆曲線投影在冠狀面 (coronal plane) 之脊突角度在兩種擺位情況的差異。二維 X 光影像與三維脊柱骨盆曲線投影在冠狀面影像的相關性;及三維脊柱骨盆曲線與壓力中心位移的相關性用*皮爾森相關* (*Pearson's correlation*)作分析。

結果：X 光影像的結果顯示，有軀幹側支撐的座位，受試者的科布角度，脊突角度及側彎指數都明顯較小(p = 0.005 ~ 0.043)。科布角度，脊突角度及側彎指數的改善比率分別為 31.38%，31.69%及 23.71%。從 X 光影像與三維脊柱骨盆曲線投影在冠狀面影像所得的脊突角度二者間有明顯的相關性(r = 0.624, p = 0.010)。但軀幹各部分與骨盆間的相對移動角度在兩種座位間的差異卻不顯著。有軀幹側支撐時，所有受試者的臀部最高壓力值都降低。

結論：藉由 X 光影像分析可知，利用有側支撐的坐姿擺位系統達到靜態矯正脊柱側彎的作用。但在三維脊柱骨盆運動分析中卻沒有顯示相同的現象，可能是因為計算方法的不同。此議題仍待未來研究的進一步驗證。

關鍵詞：脊柱側彎；姿勢；特殊擺位；軀幹側支撐；脊髓損傷

Abstract

Objective. To investigate the effects of lateral trunk supports (LTSs) of special seating on spinal and pelvic alignment for the spinal cord injured (SCI) persons with scoliosis.

Background. Special seating has been widely used in clinic to improve sitting postures of SCI persons. However, little has been known about the effects of LTSs on the scoliotic curve and buttock pressures.

Methods. Eight male SCI subjects with scoliosis participated in this study. The shapes of the spine and pelvis were measured with subjects sitting on an experimental chair in two seating configurations. Radiographs were taken first and then 3-dimensional (3-D) spine-pelvis curve and buttock pressures were measured simultaneously using a motion analysis system (Vicon 512, Oxford Metrics, U. K.) and a pressure plate (Tekscan Advanced Clinseat, U.S.A.). The severity of scoliosis was described by Cobb angles, spinous process angles, and scoliotic index calculated from the radiographic images. *Paired-t* test was used to compare differences of the Cobb angles, spinous process angles and scoliotic index as well as

the corresponding angles calculated from the coronal projection of the 3-D spine-pelvis curve between two seating configurations. Relationships between the results from 2-D radiographs and coronal projection of the 3-D spine-pelvis curves, and between the results from 3-D spine-pelvis curves and COP movements were analyzed by Pearson's correlation.

Results. The results of the radiographic data revealed that Cobb angles, spinous process angles, and scoliotic index with LTSs were all significantly smaller than those without LTSs ($p = 0.005 \sim 0.043$). The scoliosis correction rate in terms of Cobb angles, spinous process angles, and scoliotic index from the radiographs were 31.38% (14% ~ 50%), 31.69% (-7% ~ 69%), 23.71% (-27% ~ 54%) respectively. Spinous process angles on A-P radiographs and coronal projection of the 3-D spine-pelvis curves were obviously correlated ($r = 0.624$, $p = 0.010$). But there was no significant difference in relative positions of the 3-D spine-pelvis curves between the two seating configurations. With LTSs, peak pressures at the buttock were smaller than those without LTSs for all subjects.

Conclusions. Significant static correction of the scoliotic spine could be achieved by special seating with lateral trunk supports as shown by radiographic analysis results. But kinematic analysis of 3-D spine-pelvis movements did not show the same phenomenon, which could be related to the calculated methods. Further study on this issue is necessary.

Keywords: Scoliosis; Posture; Special seating; Lateral trunk supports; Spinal cord injury

Background and Purpose

Wheelchairs are very important for SCI persons to live actively, independently and productively. Abnormal sitting postures are common in wheelchair-bonded SCI persons due to poor trunk stability combined with poor wheelchair seating system. Scoliosis in terms of a lateral curvature of the spine is often found in SCI persons. Special seating has been widely used in clinic for individuals with poor trunk stability or sitting balance (Holmes et al., 2003). For persons with scoliosis, the lateral trunk supports (LTS) were one of the basic components in seating prescriptions. However, there were few researches provided objective evidences on how the LTSs influenced or managed the scoliosis. Besides, there were also many problems and limitations in the methods and measurement tools for assessing the effect of special seating. Thus this study was intended to investigate the effects of LTSs on the spinal and pelvic alignment for SCI persons through various scientific measurements.

The purposes of this study were described as follows: (1) to validate the effect of LTSs on the spinal and pelvic alignment for SCI persons through radiographic, kinematic and kinetic measurements, (2) to realize the relationship of the spinal and pelvic alignment as well as buttock pressures through integrating the kinematic and kinetic measurement results.

Method

Eight male volunteers (age: 36.9±7.3 yr, height: 167.0±5.0 cm, weight: 61.9±6.6 Kg) participated in the present study. Subjects that met the following criteria were selected: (1) C4-T12 SCI males, (2) onset over 1 year, (3) sitting on the wheelchair more than 4 hours per day, (4) diagnosed thoracic or lumbar scoliosis through A-P radiographs, (5) scoliosis can be partially corrected through manual manipulation.

An adjustable seating chair was used to simulate the actual wheelchair. The backrest was composed of several 5-8 cm wide adjustable transparent acrylic boards that provided good back support for the subject. Similarly, traditional lateral trunk support sponge pads were replaced by adjustable transparent acrylic pads.

In the x-ray room, the subject sat relaxed on the chair without any extra support except the seat belt and the foot rests. Two separate radiographs (including upper and lower trunk) in the anteroposterior (A-P) directions for

each subject were taken with a digital radiographic imaging system (Saturn 9000 M, Comed., Korea). Without moving the subject, LTS was then added following three-point support principle by an experienced occupational therapist based on the shape of the subject's spinal curve. Another 2 radiographs similar to without-LTS condition were also taken. A reseau grid plate with lead dots distributed was placed between the subject and intensifier. The grid was used for subsequent correction of image distortions.

Cobb angles were calculated with a house-developed software system in Matlab 6.1 (Mathworks, U.S.A.). Paired-t test was used to compare the difference of Cobb angles between the two seating configurations (without and with LTS) (SPSS 11.0, SPSS Inc, U.S.A.).

A 6-camera motion analysis system (Vicon 512, Oxford Metrics, U. K.) was used to measure the spatial coordinates of the markers, from which the alignment of the spine and pelvis relative to the chair was calculated. 15mm diameter markers and marker arrays (clusters, 4 markers in a set) were used to describe the spatial location of the body segments. The body-interface pressure was measured with a pressure plate (Tekscan Advanced Clinseat, U.S.A.) with approximately 2,000 individual pressure sensels. The integrating measurement system was constructed through synchronizing the kinematic measurement system and kinetic measurement system in order to record the data simultaneously.

The relative movements between upper trunk and middle trunk, middle trunk and lower trunk, lower trunk and pelvis, pelvis and experimental chair in the 3-D spine-pelvis model were analyzed with programs in Matlab 6.5. A paired-t test was further used to test the differences in the relative movements between upper trunk and middle trunk, middle trunk and lower trunk, lower trunk and pelvis, pelvis and experimental chair for two seating configurations (without and with LTSs). Effect size was further used to modify the results due to modest sample size.

Results

The results based on the radiographic data indicated that LTSs gave significantly smaller mean Cobb angles, spinoue process angles and scoliotic index compared to seats without LTSs for all subjects respectively ($8.10° \pm 2.04°$; $p = 0.005$; $7.70° \pm 3.00°$; $p = 0.037$; 0.08 ± 0.03; $p = 0.043$). In addition, the scoliosis correction rate calculated with Cobb angles, spinoue process angles and scoliotic index between two seating configurations were 31.38% (14% ~ 50%), 31.69% (-7% ~ 69%), 23.71% (-27% ~ 54%) respectively (Figure 1).. Seats with LTSs didn't give significantly smaller spinous process angles on coronal projected image of 3-D spine-pelvis curve compared to seats without LTSs ($p = 0.238$). Due to small sample size in this study, effect size was further used to examine whether there were significant differences of the relative movements among spinal segments and pelvis between the two seating configurations. Medium to large effect size ($0.5<d<0.8$) was noted after using LTSs during rotation between head and upper trunk (ROHU), flexion/ extension angles between head and upper trunk (FEHU), and flexion/ extension angles between middle trunk and lower trunk (FEML). Based on the results of 3-D data, seats with LTSs could provide some effects on correcting the sitting postures.. Peak pressures at the buttock were decreased for all subjects..

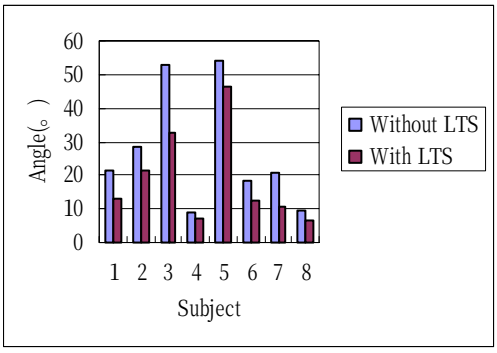

Fig 1. Cobb angles on the subjects' A-P radiographs in two static seating configurations (without and with LTS)

Discussion

The present study was the first study to

incorporate radiography, 3-D kinematic, kinetic methods to investigate the effects of special seating--LTSs on the spinal and pelvic alignment for the SCI persons with scoliosis.

Based on the radiographic results, providing LTSs for SCI persons with scoliosis could improve the spinal alignment and sitting postures. In this study, indices for measuring severity of scoliosis also discussed. The results would provide information for future research and clinical use while measuring scoliosis.

Although, no significant differences of relative movement angles between spinal segments and pelvis were found with LTSs ($p>0.05$). Nevertheless, the results showed medium to large effect size on angle of ROHU, FEHU, and FEML with LTSs. There was still a tendency found from the results of effect size. The results by X-ray and 3-D data might imply that movements of spine and pelvis were three dimensional and very complicated. The other possible reasons for the non-significant differences in 3-D kinematic results might include (1) simplification of the 3-D spine-pelvis curve; (2) 3-D calculation methods of the spinal and pelvic alignment. Further study is needed to modify the 3-D calculation methods of the spinal and pelvic alignment.

五、計畫結果自評

目前文獻上尚缺乏輪椅擺位系統之功效之客觀實證，本研究克服研究方法上之種種技術困難（如坐在輪移中拍攝Ｘ光），及試圖建立脊柱骨盆之之三維動作計算模式，雖由 Ｘ 光攝影結果已初步印證輪椅擺位系統之效用，但三維動作計算模式，及其與Ｘ光攝影結果之比對仍有待後續發展。

參考文獻

Alm, M., Gutierrez, E., Hultling, C., & Saraste, H. (2003). Clinical evaluation of seating in persons with complete thoracic spinal cord injury. *Spinal Cord, 41*(10), 563-571.

Bolin, I., Bodin, P., & Kreuter, M. (2000). Sitting position - posture and performance in C5 - C6 tetraplegia. *Spinal Cord, 38*(7), 425-434.

Brown, J. C., Swank, S. M., Matta, J., & Barras, D. M. (1984). Late spinal deformity in quadriplegic children and adolescents. J Pediatr Orthop, 4(4), 456-461.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cook, A. M., & Hussey, S. M. (2002). Seating systems as extrinsic enablers for assistive technologies. In A. M. Cook & S. M. Hussey (Eds.), *Assistive Technologies: Principles and Practice* (2nd ed., pp. 165-211). St. Louis: Mosby, Inc.

Fuhrer, M. J., Garber, S. L., Rintala, D. H., Clearman, R., & Hart, K. A. (1993). Pressure ulcers in community-resident persons with spinal cord injury: prevalence and risk factors. *Arch Phys Med Rehabil, 74*(11), 1172-1177.

Garrett, A. L., Perry, J., & Nickel, V. L. (1961). Paralytic scoliosis. *Clin Orthop, 21*, 117-124.

Greenspan, A. (2000). Scoliosis and Anomalies with general affect on the skeleton. In A. Greenspan (Ed.), *Orthopedic Radiolody : A Practical Approach* (3rd ed., pp. 891-930). Philadelphia: Lippincott Williams & Wilkins.

Harms, M. (1990). Effect of wheelchair design on posture and comfort of users. *Physiotherapy., 76*(5), 266-271.

Hastings, J. D., Fanucchi, E. R., & Burns, S. P. (2003). Wheelchair configuration and postural alignment in persons with spinal cord injury. *Arch Phys Med Rehabil, 84*(4), 528-534.

Herzenberg, J. E., Waanders, N. A., Closkey, R. F., Schultz, A. B., & Hensinger, R. N. (1990). Cobb angle versus spinous process angle in adolescent idiopathic scoliosis. The relationship of the anterior and posterior deformities. *Spine, 15*(9), 874-879.

Hobson, D. A., & Tooms, R. E. (1992). Seated lumbar/pelvic alignment. A comparison between spinal cord-injured and noninjured groups. *Spine, 17*(3), 293-298.

Holmes, K. J., Michael, S. M., Thorpe, S. L., & Solomonidis, S. E. (2003). Management of scoliosis with special seating for the non-ambulant spastic cerebral palsy population--a biomechanical study. *Clin Biomech (Bristol, Avon), 18*(6), 480-487.

Janssen-Potten, Y. J., Seelen, H. A., Drukker,

J., Huson, T., & Drost, M. R. (2001). The effect of seat tilting on pelvic position, balance control, and compensatory postural muscle use in paraplegic subjects. *Arch Phys Med Rehabil, 82*(10), 1393-1402.
Keim, H. A. (1978). Scoliosis. *Clin Symp, 30*(1), 1-30.
Koo, T. K., Mak, A. F., & Lee, Y. L. (1996). Posture effect on seating interface biomechanics: comparison between two seating cushions. *Arch Phys Med Rehabil, 77*(1), 40-47.
Magee, D. J. (2002). Assessment of Posture. In D. J. Magee (Ed.), *Orthopedic Physical Assessment* (4th ed., pp. 873-903). Philadelphia: Saunders.
Salerno, S., & Kirshblum, S. (2002). Wheelchairs/adaptive mobility equipment and seating. In S. Kirshblum, D. I. Campagnolo & J. A. Delisa (Eds.), *Spinal Cord Medicine*. Philadelphia: Lippincott Williams & Wilkins.
Vaccaro, A. R., & Silber, J. S. (2001). Post-traumatic spinal deformity. *Spine, 26*(24 Suppl), S111-118.
Zollars, J. A. (1993). *Special Seating* (3rd ed.). Santa Cruz: PAX Press.