行政院國家科學委員會專題研究計畫 期中進度報告

脊髓損傷患者輪椅坐姿擺位系統的功能探究(1/2)

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行政院國家科學委員會補助專題研究計畫成果報告

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編號：NSC 91-2314-B-002-393

執行單位：台大醫學院職能治療學系

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一、中文摘要

背景與研究目的：

百分之七十至八十的脊髓損傷(SCI)患者必須長期乘坐輪椅，以維持行動及各項功能活動，SCI 患者由於喪失軀幹肌力，無法維持良好坐姿，故而產生許多併發問題，如脊柱與骨盆之關節變形、疼痛、坐姿耐力不良、壓瘡、心肺功能差等。因此，良好的坐姿擺位系統是提供 SCI 患者之重要復健內容。然而許多輪椅坐姿擺位的建議處方，雖然在臨床上廣泛使用，但其功能成效的驗證仍非常欠缺。現有文獻多針對坐姿擺位對於臀部壓力的影響作探討，卻少有就脊柱與骨盆姿勢的矯治作用深入研究，主要是因為使用輪椅之 SCI 患者其脊柱與骨盆位置的量測困難，至今尚無精確、客觀而量化之方法。

臨床上一致認為良好擺位的關鍵在於骨盆前後傾斜的角度及脊柱的姿勢。已有文獻分別探討不同坐姿傾角與骨盆位置；以及坐姿傾角與臀部壓力的關聯性，然而未有文獻能解釋上列坐姿傾角、骨盆與脊柱相對位置，及臀部壓力三者之關聯性，以供臨床擺位處方時之參考準則。

第一年計畫前期，致力於建立三維電腦量測技術、臀部壓力測量與三維電腦量測系統的同步連接，及製作調整型量製輪椅，目前已見製完成，先進行正常人坐在不同坐椅傾角時，對於骨盆位置及臀部壓力的影響探究，正將進行脊髓損傷患者之測試。

目前共有六位健康男性（年齡 22 至 29 歲）參與本研究。受試者坐於可調整座深、腳踏板高度及坐椅傾角的調整式坐椅。受試者身上特定解剖位置，及調整椅上貼附紅外線反光標記，以六個照相機拍攝並由紅外線立體動作分析系統（Vicon, Oxford Metrics, U.K.），可求得脊柱與骨盆之三維關節位置及角度。另整合壓力感應墊（Advanced Clinseat, U.S.A.）同步量測臀部壓力之峰值（peak value）及其位置。實驗將比較四種不同座椅傾角（0°, 5°, 10°, and 15°）、骨盆位置及臀部壓力。

結果顯示骨盆後傾角度會隨座椅後傾角度擴大而增加，而當座椅後傾時，臀部壓力峰值減少且位置會隨之後移。由於臨床上常因防止個案張力過大易向前滑出、壓力舒緩等目的而建議將輪椅座椅後傾，然而亦有文獻指出骨盆前傾可減少下背痛情形的發生，此不同的建議，故需在座椅傾角、臀部壓力與骨盆位置，及乘坐者功能與舒適度等因子間做一完整考量。

未來仍需收集更多受試者，並瞭解脊髓損傷及各種診斷患者的資料，及比較與健康受試者之異同。

Abstract:

Background and Purpose— Correct postures can prevent wheelchair-bound individuals from deformity and pressure sores. The key to a good sitting posture lies in controlling the anteroposterior tilt of the pelvis and the shape of the spine. Previous studies have examined either the effect of seated posture on body-seat interface pressure, or the effect of tilted seated position on pelvic alignment. There is however no study on the relationship among the seated posture, pelvic alignment and interface pressure. The purpose of this pilot study was to bridge the gap by establishing the relationship between tilted seated positions, pelvic alignment and the maximum pressure on body-seat interface in healthy subjects.

Methods— Six healthy male volunteers

aged 22 to 29 years were included in this study. They sat on an adjustable experimental wheelchair. Reflected markers were attached to specific body anatomical landmarks and the experimental chair to describe the three-dimensional positions of the body segments and the chair. 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 pelvis relative to the chair was calculated. The body-interface pressures were measured using a pressure plate (Advanced Clinseat, U.S.A.) with approximately 2,000 individual pressure sensors. Alignment of the pelvis and the pressure distribution were measured synchronized for four tilted sitting positions (0°, 5°, 10°, and 15°). Maximum pressures and their positions were obtained for each test condition.

Results— The pelvis tilted posteriorly while the back support of the chair was tilted backwards. The maximum pressure decreased when chair tilted angle was increased. Maximum pressure point displaced posteriorly as the chair tilted backwards.

Discussion— Previous studies have suggested that a correct sitting posture is obtained by tilting the pelvis anteriorly to create a lumbar spine lordosis. The present study showed that the pelvis tilted posteriorly while the chair tilt angle was increased. It seems therefore that the chair should not be tilted backwards too much to maintain an anteriorly tilted pelvic position in order to prevent low back pain. The maximum pressure decreased when chair tilted angle was increased, in agreement with findings in the literature. Although only 6 subjects were included in the present study, qualitative relationship between tilted seated positions, pelvic alignment and the maximum pressure on body-seat interface in healthy subjects was obtained. Further study on patients is necessary to confirm the present findings.

二、緣由與目的

The purpose of seating is to improve pressure distribution, alignment and comfort [1]. Adequate posture has been defined as a posture where muscle tension is minimized and support forces are equally distributed [2]. In normal subjects, incorrect posture can cause back pain because it increases the load on the intervertebral discs and increases the stress on the posterior structures of the back [3-6]. Different chairs and supports have been studied to maintain the normal curves of the spine during sitting.

From the previous literatures, the correct sitting posture can be suggested through tilting the pelvis anteriorly and making the lumber spine toward lordosis [7]. Pelvic tilt dictates the curves of the spine because of the position of the sacrum, shared by these two structures. Therefore, the key to a good sitting posture lies in controlling the anteroposterior tilt of the pelvis and the related shape of the spine [8].

It is generally accepted that the main cause of pressure sores is the prolonged application of external pressure with both the amount of pressure and the length of time it is applied being of importance [9]. In recent years, some investigators have examined the effectiveness of passive pressure relief techniques, the manipulation (e.g. tilting or reclining) of the individual’s seated posture by some external force, and they all found significant differences in interface pressure compared to a neutral position [10-12].

The purpose of this study was to investigate the effect of tilted seated position on pelvic alignment and pressure distribution in healthy subjects.

三、方 法：

Subjects

Six normal male volunteers were recruited in this study (mean age 25 years old). None of them had spinal or pelvic problems before. Their demographic data were described in table1.

Experimental equipments

Kinematic data were collected with a Vicon 512 (Oxford Metrics Ltd., Oxford, England), consisting of six infrared cameras. 9mm diameter markers were used to describe the spatial location of the segment .Video capture rate was 60Hz.

Kinetic data were collected with Advanced Clinseat (Tekscan Clinical Seating Pressure Assessment System), consisting of approximately 2,000 individual pressure sensing locations, which are referred to as 'sensing elements', or 'sensels'. The sensels are arranged in rows and columns on the sensor. Each sensel can be seen as an individual square on the computer screen by selecting the 2-D display mode. The digital output of each sensel is divided into 256 increments, and displayed as a value (raw sum) in the range of 0 to 255 by the software. Pressure plate capture rate was 8Hz. The kinematic data were post processed by using linear interpolation to increase the frequency to 60Hz for analysis.

An adjustable chair with 0.5m seat width, adjustable seat depth, seat-to-backrest ,and seat angle was used in the study.

Testing procedures

1. We calibrated Vicon system first in order to make sure all markers can be seen by cameras.
2. Reflected markers were placed over bony landmarks on the trunk, shoulder, arm, pelvis, thigh and knee. Besides, four markers were placed on the four corners of pressure plate, and six markers on the chair (Figure 1, and table 2).
3. Subject flexed hip to about 90 degrees in order to point IT (ischial tuberosity). This technique was defined position of IT related to pelvis local coordinate.
4. Subjects were tested while seated on the experimental chair. The experimental chair was easily and reliably adjusted to position subjects into each of the four test positions. The Advanced Clinseat was affixed to the surface of the experimental chair; subjects were seated directly on the Clinseat. Seat depth and footrest height were adjusted to the subject's body measurements.
5. Proceeding equilibrium, sensitivity adjustment, and calibration.
6. The chair was then tilted-in-space from 0° to 5°, 10°, and 15°. Alignment of the pelvis and the pressure distribution were recorded simultaneously with Vicon system and Tekscan Clinical Seating Pressure Assessment System.

Data collection

Subject sat on the experimental chair. Kinematic and kinetic data were collected synchronized via a pointer. The seat angle started from 0^o at first. After pointer contacted the pressure plate, the data collection begun, we proceeded a static trial and ensured no markers lost. Then we changed the seat angle to $5^o, 10^o, 15^o$.

Data analysis

1. Local pelvis coordinate system

As Figure 2, we defined pelvis coordinate system：

$$\overrightarrow{z_P} = \frac{\overrightarrow{P_{RASI}} - \overrightarrow{P_{LASI}}}{\left|\overrightarrow{P_{RASI}} - \overrightarrow{P_{LASI}}\right|}$$

$$\overrightarrow{y_P} = \frac{\left(\frac{\overrightarrow{P_{RPSI}} + \overrightarrow{P_{LPSI}}}{2} - \frac{\overrightarrow{P_{RASI}} + \overrightarrow{P_{LASI}}}{2}\right) \times \overrightarrow{z_p}}{\left|\left(\frac{\overrightarrow{P_{RPSI}} + \overrightarrow{P_{LPSI}}}{2} - \frac{\overrightarrow{P_{RASI}} + \overrightarrow{P_{LASI}}}{2}\right) \times \overrightarrow{z_p}\right|}$$

$$\overrightarrow{x_P} = \overrightarrow{z_P} \times \overrightarrow{y_P}$$

Origin of pelvis coordinate system was $\frac{\overrightarrow{P_{RASI}} + \overrightarrow{P_{LASI}}}{2}$ 。

2. Local pressure plate coordinate system

As Figure 3, we defined pressure plate coordinate system：

$$\overrightarrow{x_{pp}} = \frac{\overrightarrow{P_{RLPP}} - \overrightarrow{P_{LLPP}}}{\left|\overrightarrow{P_{RLPP}} - \overrightarrow{P_{LLPP}}\right|}$$

$$\overrightarrow{y_{pp}} = \frac{\vec{x}_{pp} \times (\vec{p}_{LUPP} - \vec{p}_{LLPP})}{\left|\vec{x}_{pp} \times (\vec{p}_{LUPP} - \vec{p}_{LLPP})\right|}$$

$$\overrightarrow{z_{pp}} = \overrightarrow{x_{pp}} \times \overrightarrow{y_{pp}}$$

Origin of pelvis coordinate system was $\vec{p}_{LLPP}$ 。

We defined IT coordination on pelvis coordinate system, then transformed to the pressure plate coordinate system and projected from spatial space to plane of pressure plate. Compared the projected points and the locations of maximum pressure where we found on right and left side of pressure plate.

四、結 果

Pelvic tilt angle change in different chair tilted angles is shown in figure 4. Pelvic tilt angle increased while chair tilted angle was increased.

The location of ischial tuberosity and maximal pressure point in six subjects are shown in figure 5. We found that the maximal pressure point displaced more posteriorly as the chair tilted angle increased. There were some distances between ischial tuberosity and maximal pressure point in all subjects' results. However, we could not find obvious tendency between the distance and the chair tilted angle.

The result of maximal pressure in different chair tilted angles is shown in figure 6. It seems that maximal pressure decreased when chair tilted angle was increased except in subject 2 (Figure 6).

五、討 論

The first purpose of this study was to investigate the effect of tilted chair on pelvic alignment. Pelvic tilt angle increased while chair tilted angle was increased. That is, the more we tilted the chair, the more pelvis tilted posteriorly. Pelvis tilted posteriorly can cause back pain due to increasing load on the intervertebral discs and posterior structures of the back. To prevent low back pain, we should not tilt the chair too much backwards.

The second purpose of this study was to investigate the effect of tilted chair on pressure distribution in normal subjects. We found that the maximal pressure point displaced more posteriorly as the chair tilted angle increased. The maximal pressure decreased when chair tilted angle was increased except in subject 2.The result was similar to the previous studies [9-12]. Besides, increased chair tilted angles can displace the maximal pressure point posteriorly and reduce the maximal pressure on the buttock simultaneously through back support of the chair. But tilted chair will limit the reaching areas of upper extremities and increase the load of the cervical spine muscles when performing daily activities.

Some measurement errors came from the palpation of the positions of the markers on the body surface and skin displacement. It is a pity that we are not sure whether the maximal pressure point in the buttock during sitting is ischial tuberosity or not. Further research can prevent the measurement errors through accurate palpation.

Our study involved only 6 participants, statistical analysis was limited. However, we still can find some tendencies in the results. More subjects will be included in the further research.

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附錄：

Table 1. Demographic data of the subjects

	Age (y/o)	Body weight (kg)	Height (cm)	Thigh length (cm)	Shank Length (cm)	Shoulder to ground height (cm)
Subject 1	22	52.5	170	48	43	70
Subject 2	24	64	171	43	43	64
Subject 3	29	75	178	48	44	73
Subject 4	28	70	176	50	44	72
Subject 5	23	60	176	47	43	73
Subject 6	24	80	167	48	41	71

Table 2. Location of markers

Position			
Trunk		Shoulder, forearm, and elbow	
SN	Sternal notch	AC	Acromion
XP	Xphoid process	FR	Forearm
C7	7th Cervical spinal process	EMEP	Elbow medial epicondyle
T10	10th Thoracic spinal process	ELEP	Elbow lateral epicondyle
		WRB	Ulnar styloid
Pelvis		WRA	Radius styloid
ASI	Anterior superior iliac spine	FIN	Tip of thirth finger
PSI	Posterior superior iliac spine		
GT	Great trochanter		

Figure 1. The subject sit on an adjustable chair which may change the seat depth, the height of foot pad, and seat tilt-angle. The markers were placed on the subject, pressure plate, and chair.

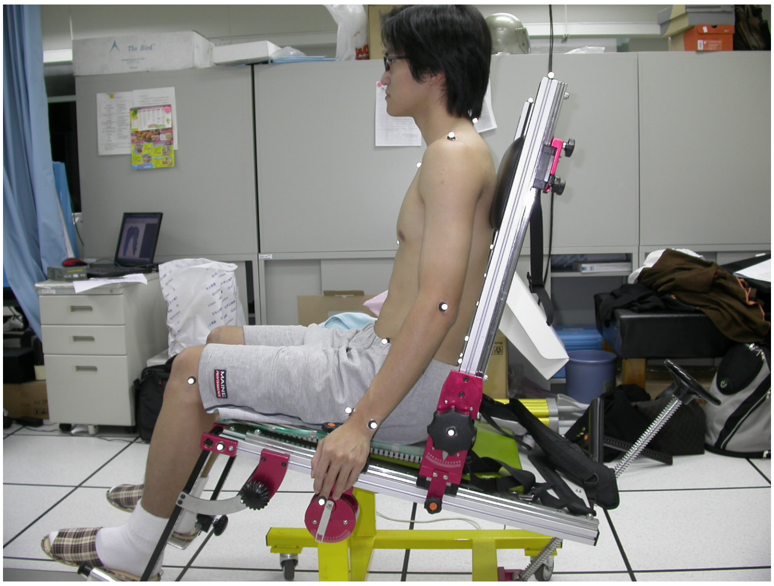

Figure 2. Pelvis coordinate system

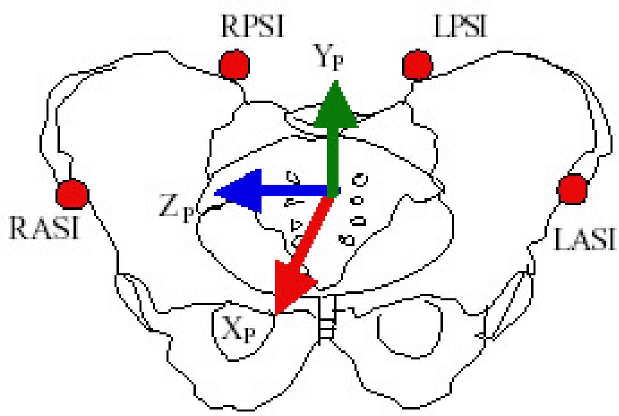

Figure 3. Pressure plate coordinate system

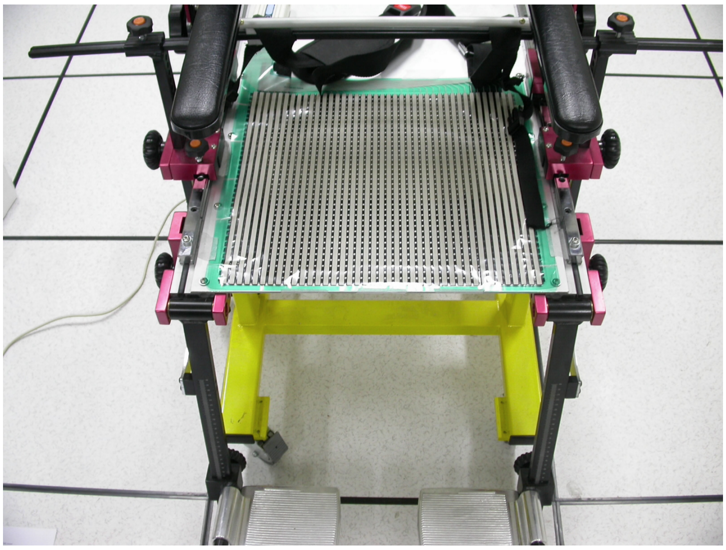

Figure 4. Pelvic tilt angles in different chair tilted angles

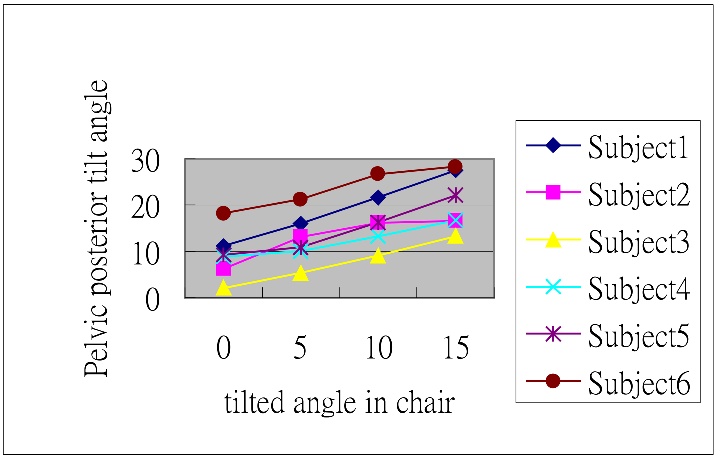

Figure 5. The location of ischial tuberosity and maximal pressure Circle represented the maximum pressure position. Star represented the position of IT projected to pressure plate coordinate system.

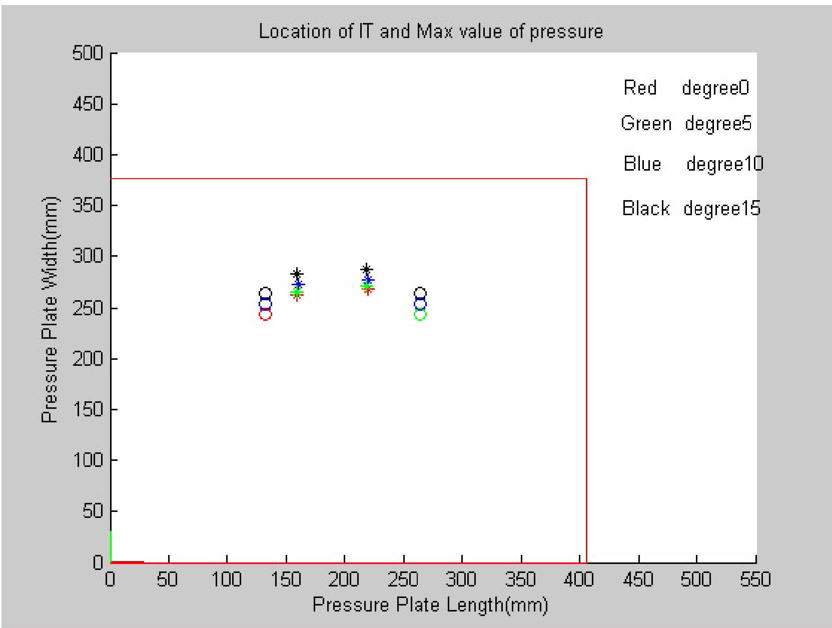

Figure 6. Maximal pressure in different chair tilted angles