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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腦中風病患的快速跨步對患者跌倒的預測與預防：控制機轉及臨床應用 (3/3)

(Fast Stepping in Stroke Patients for Fall Prediction and Prevention Control Mechanisms and Clinical Implications 3/3)

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計畫類別：■個別型計畫　□整合型計畫

計畫編號：NSC 90-2314-B-002-405

執行期間：90 年 8 月 1 日至 91 年 7 月 31 日

計畫主持人：湯佩芳助理教授　台大醫學院物理治療學系暨研究所

共同主持人：林光華教授　台大醫學院物理治療學系暨研究所

計畫參與人員：賴金鑫教授　台大醫學院醫學系

鄭素芳副教授　台大醫學院物理治療學系暨研究所

陽毅平教授　台灣大學機械系

陳淑玲研究生　台大醫學院物理治療學系暨研究所

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執行單位：台大醫學院物理治療學系暨研究所

中　華　民　國　九十一　年　十　月　三十一　日

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中文摘要

本研究目的在探討腦中風患者與健康成人受到較慢速及較快速的前、後、左、右四個方向腰部牽拉干擾時，在不受指令限制下所採取之平衡反應策略、足底壓力中心移動軌跡形式、與足底壓力中心相關參數之異同。共 12 位健康成人（51.9 ± 12.8 歲）與 12 位輕中度腦中風患者（52.8 ± 12.4 歲）參與本研究。以人體牽拉系統施予受試者前、後、左與右四個方向，較慢速（10 公分/秒）與較快速（30 公分/秒）牽拉干擾測試各 3 次，牽拉距離均為 10 公分。總共為 24 次之腰部牽拉干擾測試。結果顯示腦中風患者採取跨步平衡反應策略之頻率百分比（53.1%）較健康成人（29.5%）高（$p<0.001$）。當採取固定支撐底面積平衡反應策略以因應牽拉干擾時，兩組人在足底壓力中心移動軌跡形式相似。但在足底壓力中心相關參數方面，腦中風患者在較慢速及較快速向前牽拉時之足底壓力中心移動軌跡長度、移動平均速率，及較慢速與較快速向右牽拉時之與牽拉方向相平行方向之足底壓力中心最大移動振幅均小於健康成人($p<0.05$)。而在較慢速向前牽拉時之與牽拉方向相垂直方向之足底壓力中心最大移動振幅則大於健康成人($p<0.05$)。當採取跨步平衡反應策略以因應牽拉干擾時，兩組人在受到向前或後牽拉干擾而採取向前或後跨步策略時之足底壓力中心移動軌跡形式亦相似。但腦中風患者在受到向健側之牽拉干擾且產生以健側腳向牽拉方向跨步之平衡反應時，足底壓力中心形式異於健康人。採用跨步策略時，兩組人在足底壓力中心相關參數上無明顯差異（$p>0.05$）。

本研究顯示輕中度腦中風患者在受到腰部牽拉干擾時多採取健側腳跨步之平衡反應策略以恢復平衡，尤其在受到向後牽拉干擾時。當腦中風患者採取固定支撐底面積策略時，會盡量減少身體重心的移動，避免其超出支撐底面積外而失去平衡；並利用增加與牽拉方向相垂直方向之足底壓力中心的移動來代償其平衡上的缺失。當腦中風患者採用跨步策略維持平衡時，因是以健側腳跨步，故與健康成人在足底壓力中心相關參數上無明顯差異。

關鍵詞：腦中風患者、腰部牽拉干擾測試、平衡反應策略、足底壓力中心移動軌跡形式、足底壓力中心相關參數

Abstract

This study investigated the balance strategy, as well as center of pressure (COP) trajectory and parameters between healthy adults and patients with hemiplegia in response to slow fast pulling-speed and perturbations in 4 directions (forward, backward, left and right). Twelve healthy adults and 12 hemiplgic patients following mild to moderate stroke participated in this study. There three 3 trials of pulling perturbations at slow (10cm/sec) and fast (30cm/sec) speeds in all four directions. Results revealed that the frequency of stepping was greater in patients with hemiplegia than in healthy adylts ($p<0.001$). The COP trajectories of patients with hemiplegia and healthy adults were similar when they used the fixed-support strategy. The COP excursion and COP velocity in slow and fast forward pulling trials, the peak-to-peak amplitude of COP displacement in the direction parallel to the perturbation in slow and fast right-side pulling were smaller in patients with hemiplegia compared to the healthy adults. . But the peak-to- peak amplitude of COP displacement in the direction orthogonal to the pulling direction in slow forward pulling trials was greater for patients with hemiplegia than for the healthy adults. The COP trajectories of patients with hemiplegia and healthy adults who used the stepping strategy in response to forward or backward pulling perturbations were similar. But the COP trajectory of patients with hemiplegia was different from that of healthy adults when these patients stepped with the unaffected leg in response to pulling perturbation from the unaffected side. There was no significant difference in COP parameters between these two groups when the stepping strategy was used. Patients with hemiplegia following mild to moderate stroke tended to use stepping strategy to recover balance in response to waist pulling perturbations compared to healthy adults. Patients with hemiplegia decreased displacement of center of mass to avoid lose of balance when they used fixed-support strategy. The fact that hemiparetic patients did not show significant differences in COP parameters compared to healthy adults may be due to that the majority of stepping strategies were carried out with the unaffected leg of the stroke patients.

Keywords：hemiplegia, waist pulling perturbation, reactive balance strategy, trajectory of center of pressure, parameters of center of pressure

Background and Aims

The ability to quickly respond to external perturbations is an important capacity of stroke patients to maintain dynamic balance in activities of daily living. The purpose of this study was to compare the balance strategy, as well as center of pressure (COP) trajectory and parameters between healthy adults and patients with hemiplegia in response to slow- and fast-speed waist- pulling perturbations in forward, left, right, and backward directions.

Methods

Subjects. Twelve patients with hemiplegia following mild to moderate stroke and 12 age-matched healthy adults participated in the study (Table 1).

Experimental Apparatus. A custom-built computerized pulling system was used to provide specified pulling forces to the subject's waist. Two force plates (AMTI OR6-5, Advanced Mechanical Technology, Inc., USA) were used to record ground reaction forces. Six foot switches (Motion Lab Systems, Inc., USA) were used to signal whether the heel and the 2nd and fifth metatarsal heads of each foot were in contact with the floor. The force and foot switch signals were all recorded on a PC computer using the DATAPAC A/D acquisition board and acquisition software (Run Technologies, USA). The DATAPAC2000 software (Run Technologies, USA) was used to analyze force and foot switch data. Custom-written software was also used to analyze the center of pressure data. Video analysis was performed to characterize the reactive balance strategies evoked by waist-pulling perturbations.

Pulling Perturbation Tests. Each subject was standing on the center of one of the force plate. During the test, the subject wore a safety harness and a belt at the waist level. A steel rope was used to attach the belt to the pulling system. The height of the pulling system was adjusted to subject's waist level. Each subject was exposed to 24 waist-pull perturbations with three each for slow- and fast-speed (10 cm/sec and 30 cm/sec, constant pulling distance= 10cm) perturbations in each of the 4 directions (forward, backward, left and right). Subjects were instructed to respond naturally. No constraint of responses was given.

Results

Chi-square analysis revealed that the frequency of stepping was greater in patients with hemiplegia than healthy adults (x^2= 33.1 , $p<0.001$). The frequency of stepping also increased as the pulling velocity increased (x^2= 5.6 , $p<0.05$). Subjects stepped most frequently when they received the backward pulling perturbations (x^2= 198.3 , $p<0.001$) (Table 2).

The COP trajectories of patients with hemiplegia and healthy adults were similar when they used the fixed-support strategy. The COP initially moved toward the pulling direction and then turned to the opposite direction. In addition, the COP excursion and COP velocity in slow- and fast-forward pulling perturbations, as well as the peak-to-peak amplitude of COP displacement in the direction parallel to the pulling direction in slow and fast rightside pulling were smaller for the patients with hemiplegia than for the healthy adults. But the peak-to-peak amplitude of COP displacement in the direction orthogonal to the pulling direction in slow forward pulling perturbations were greater for patients with hemiplegia compared with healthy adults (Figures 1-4).

The COP trajectories of patients with hemiplegia and healthy adults who used the stepping strategy in response to forward or backward pulling perturbations were similar. The COP initially moved toward the pulling direction and then turned to the opposite direction. The COP initially moved toward pulling direction and laterally toward the stepping leg and laterally toward the stance leg, and then moved toward pulling direction and laterally toward the stepping leg. A few patients with hemiplegia had an obvious loop of COP trajectories when COP trajectory moved from stepping leg to stance leg. When healthy adults received sideway pulling perturbations and used the stepping strategy, the COP initially moved toward the stance leg and then moved toward the stepping leg. But the COP trajectory of patients with hemiplegia initially moved toward stepping leg when received pulling perturbation from the unaffected side and used the unaffected leg to step toward the pulling direction. For the parameters of COP, there was no significant difference between the two groups when stepping strategy was used (Figures 5-8).

Conclusions

Patients with hemiplegia following mild to moderate stroke tended to use stepping strategy to recover balance in response to waist pulling perturbations compared to healthy adults. Patients with hemiplegia decreased displacement of center of mass to avoid lost of balance when they used fixed-support strategy. The fact that hemiparetic patients did not show significant differences in COP parameters compared to healthy adults may be due to that the majority of stepping strategies were carried out with the unaffected leg of the stroke patients.

Evaluation of the Outcomes of the Present Study

1. Although the design of this study was different from what we proposed before, findings of this study are relevant and will

have great impact on the balance training regimens for hemiparetic patients following stroke.
2. Results of this study are suitable to be published in an internationally peer-reviewed journal. We are in the process of preparing for publication.
3. A masters thesis is (ref. 1) is part of the product of this study.

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表 1：受試者基本資料

參數＼組別	健康成人組			腦中風組		
性別（男／女）	10	/	2	10	/	2
慣用側（偏癱側）：左/右	3	/	9	2	/	10
年齡（歲）	51.9	±	12.8	52.8	±	12.4
身高（公分）	163.3	±	7.8	164.1	±	5.8
體重（公斤）	63.6	±	9.0	65.8	±	10.7
發病至測試當日期間之總日數(日)				45	~	1435
伯格平衡量表得分（分）	56.0	±	0.0	48.7*	±	4.9
計時之站起與走測試（秒）	8.4	±	1.4	17.4*	±	6.5
迷你心智狀態檢查得分（分）	30.0	±	0.0	28.2*	±	1.8
傅格-梅爾下肢動作協調能力測試得分（分）				24.3	±	5.6
傅格-梅爾平衡能力測試得分 (分)				12.1	±	1.2

註：資料除性別與發病至測試當日期間之總日數外，皆以平均值 ± 標準差表示。
* 表示腦中風組與健康成人組有顯著差異，$p < .05$

表二：兩組人於八種牽拉干擾測試情境下採取跨步策略之頻率及頻率百分比

	健康成人組				腦中風組			
	慢速		快速		慢速		快速	
牽拉方向	頻率	百分比	頻率	百分比	頻率	百分比	頻率	百分比
向前牽拉	5	13.9%	10	27.8%	14	38.9%	20	55.6%
向後牽拉	30	83.3%	33	91.7%	30	83.3%	36	100.0%
向左(健側)牽拉	0	0.0%	3	8.3%	7	19.4%	11	30.6%
向右(患側)牽拉	1	2.8%	3	8.3%	18	50.0%	17	47.2%

註：頻率百分比之算法中，分子為於每種牽拉干擾測試情境下採取跨步策略之頻率，分母為：12 位受試者在每種牽拉干擾測試情境下之測試總次數(3 次/位× 12 位＝36 次)。

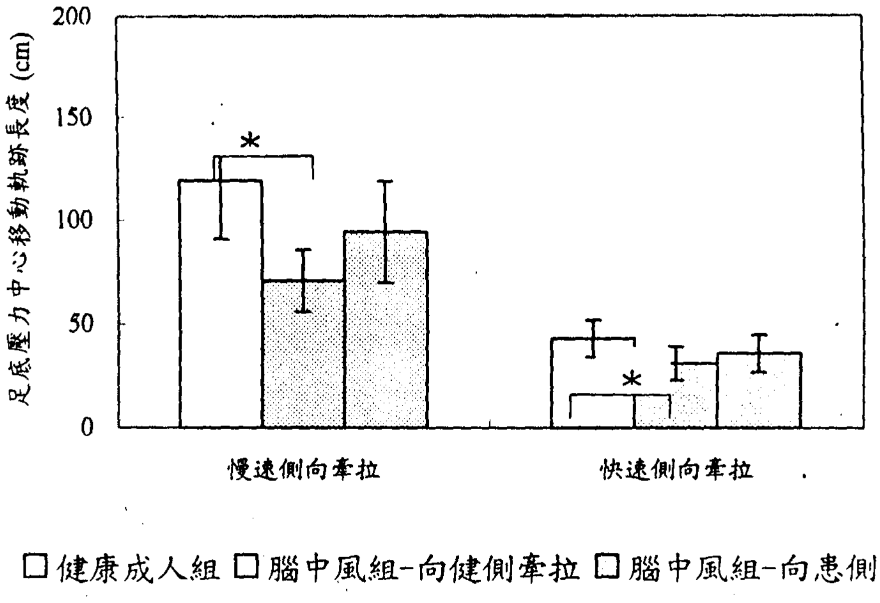

圖 1. 健康成人受到側向與腦中風患者受到向健側及向患側牽拉干擾且採取固定支撐底面積策略時之足底壓力中心移動軌跡長度

註: 1. ＊表與健康成人組有統計上顯著差異（$p<0.05$）

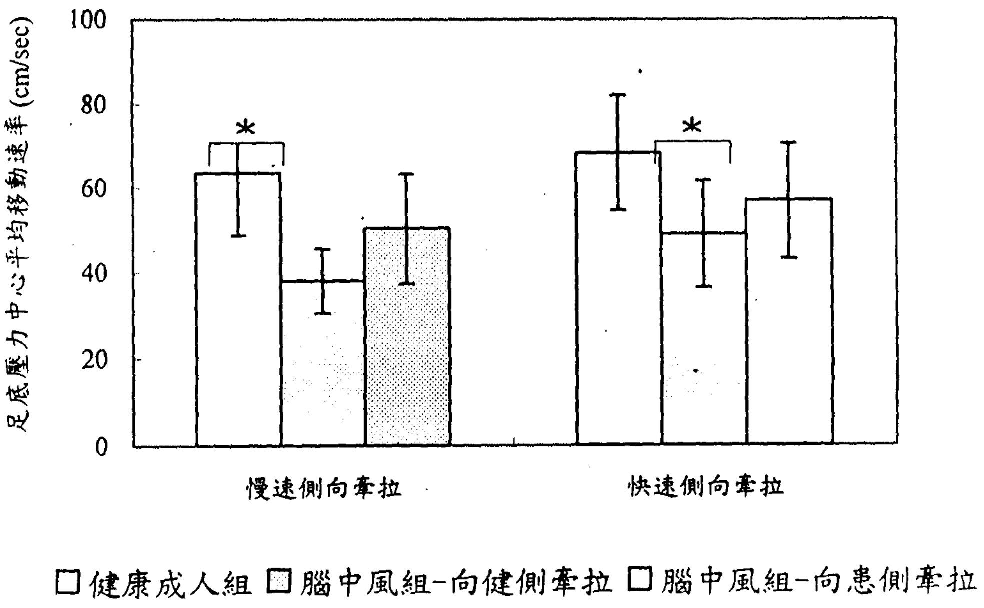

圖 2. 健康成人受到側向與腦中風患者受到向健側及向患側牽拉干擾且採取固定支撐底面積策略時之足底壓力中心平均移動速率

註: 1. ＊表與健康成人組有統計上顯著差異（$p<0.05$）

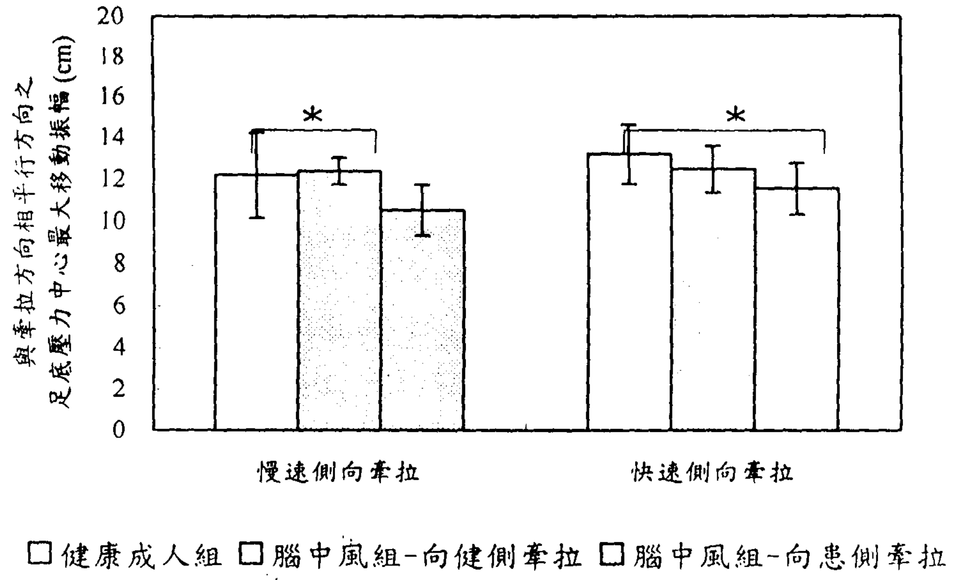

圖 3. 健康成人受到側向與腦中風患者受到向健側及向患側牽拉干擾且採取固定支撐底面積策略時之與牽拉方向相平行方向之足底壓力中心最大移動振幅

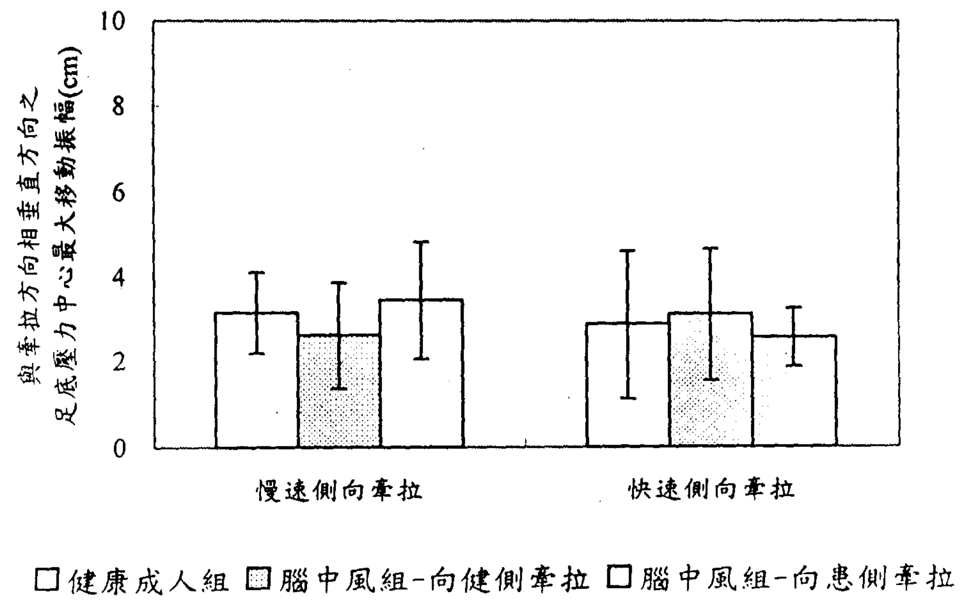

圖 4. 健康成人受到側向與腦中風患者受到向健側及向患側牽拉干擾且採取固定支撐底面積策略時之與牽拉方向相垂直方向之足底壓力中心最大移動振幅

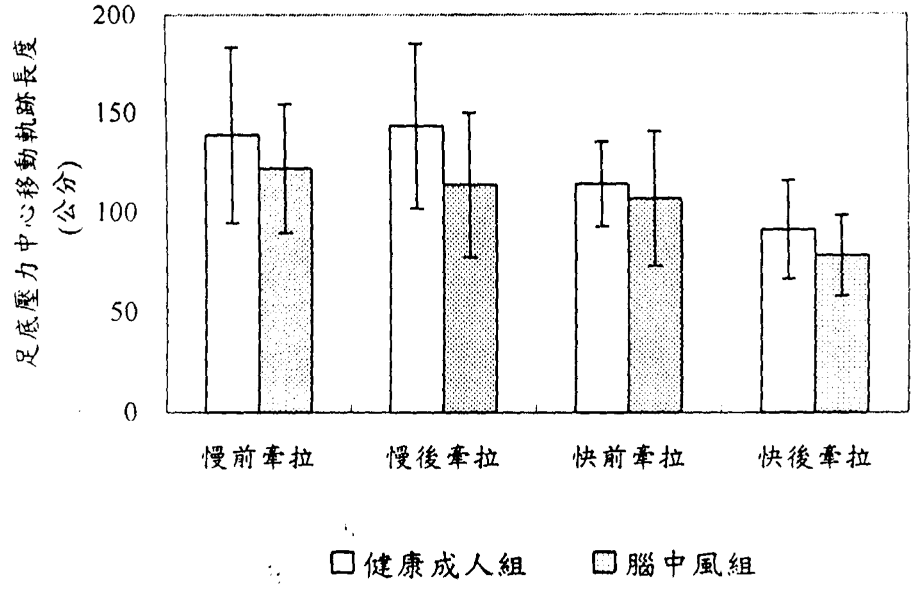

圖 5. 兩組受試者在四種牽拉干擾情境下（慢速向前、向後，快速向前、向後）採取跨步策略時之足底壓力中心移動軌跡長度

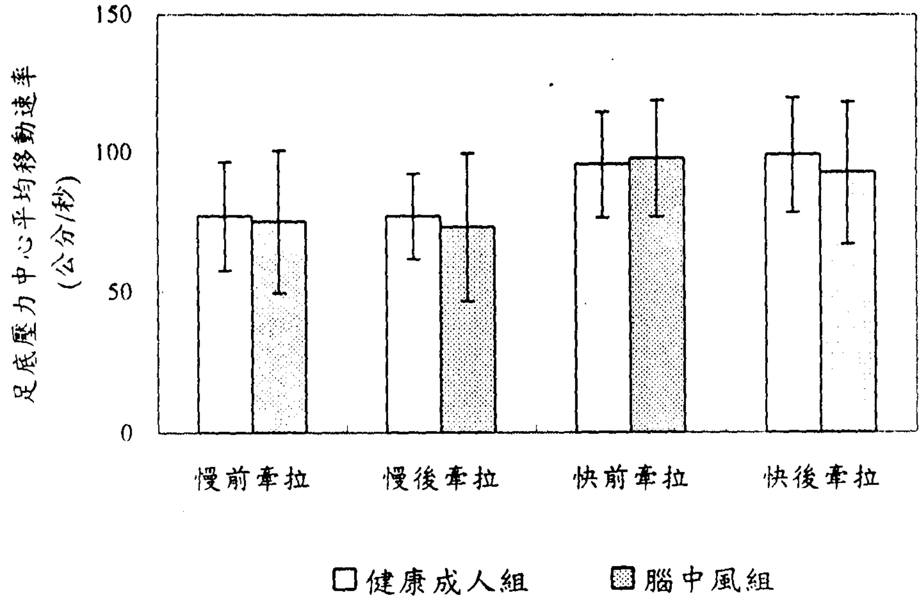

圖 6. 兩組受試者在四種牽拉干擾情境下（慢速向前、向後，快速向前、向後）採取跨步策略時之足底壓力中心平均移動速率

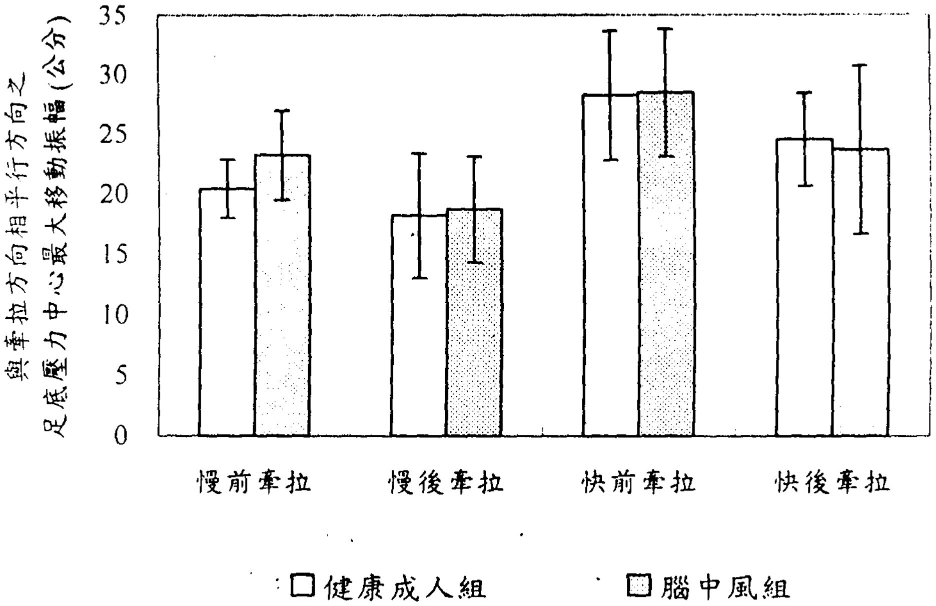

圖 7. 兩組受試者在四種牽拉干擾情境下（慢速向前、向後，快速向前、向後）採取跨步策略時之與牽拉方向相平行方向之足底壓力中心最大移動振幅

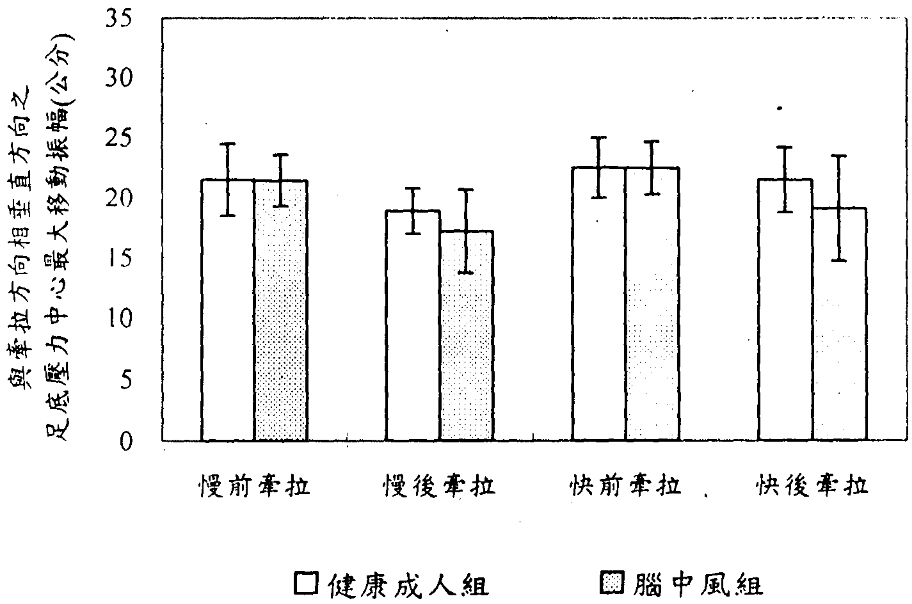

圖 8. 兩組受試者在四種牽拉干擾情境下（慢速向前、向後，快速向前、向後）採取跨步策略時之與牽拉方向相垂直方向之足底壓力中心最大移動振幅