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特刊

導入新興科技於職能治療

客座編輯：楊育昇

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Instructions for Authors

學會通訊課程說明

本會為提供更多元方式服務會員，推動「通訊課程」，以提升會員之研究知能，並擬定試題，申請衛生福利部 OT 研究通訊電子報通訊課程積分認證供會員申請，使職能治療人員取得繼續教育積分。

對 象：本會會員

辦 法：

1. 需閱讀完本會雜誌後，至台灣職能治療學會網站中，「繼續教育」之「通訊學分」處 (http://www.ot.org.tw/forms/credits) 回答雜誌中之測驗題。
2. 會員必須於下一期期刊發行前（每年6月或12月底）完成作答與回覆，否則不予計分。
3. 測驗分數達 80 分以上者，即可獲得 2 學分，可自行至衛生福利部繼續教育積分管理系統查詢。
4. 試題答案將於下一期期刊雜誌刊登。
5. 相關辦法：醫事人員執業登記及繼續教育辦法第十四條第六點。參加通訊課程者，每次積分 2 點。但超過 60 點者，以 60 點計。
6. 以上說明若有任何疑問，請洽本會秘書處。

40卷第一期 通訊課程測驗

請將答案填寫於對應的空格

虛擬實境與簡訊提醒於思覺失調症個案之應用與成效:前驅隨機對照試驗				
1	2	3	4	5

1. 有根據本文之前言，有關思覺失調症對個案的生活品質、時間使用之影響，何者不正確?
   (A) 個案有較高的心血管疾病與代謝症候群之風險。
   (B) 與常人相比，個案較多時間用於功能性活動。
   (C) 個案較常把時間用在休息，或「無所事事」。
   (D) 體能活動參與是個案復元歷程中的重要元素
2. 有關虛擬實境科技，下列何者不正確？
   (A) 此技術可以提供大量類似真實情境的練習機會。
   (B) 沉浸式虛擬實境介面經常使用頭戴顯示裝置。
   (C) 使用投影機投影擬真畫面，也是一種虛擬實境技術。
   (D) 尚未有研究使用虛擬實境技術，來治療個案的精神症狀。
3. 關於信息與通訊科技，下列何者有誤？
   (A) 使用手機、電腦、App 等科技，都算是信息與通訊科技之應用。
   (B) 國外研究發現 2007 年以後，精障者擁有手機的比率顯著提升。
   (C) 用手機簡訊做衛教，是目前有最多研究實證支持的應用方式。
   (D) 應用雙向簡訊技術，會鼓勵個案回傳簡訊來互動。
4. 有關本研究的虛擬實境介入，何者不正確?
   (A) 本研究使用頭戴顯示裝置，製造三度空間沉浸式虛擬實境體驗。
   (B) 研究中使用 App 軟體，將 Google Map 街景應用於治療。
   (C) 運動過程中使用心律表監測運動強度。
   (D) 研究中搭配跑步機設備，根據實際行走距離變化街景。
5. 有關本研究的結果，何者為是？
   (A) 結果初步支持虛擬實境健走活動之可行性。
   (B) 在介入期間，個案在週末的體能活動參與有所提升。
   (C) 簡訊提醒可以維持思覺失調症個案參與體能活動的正向改變。
   (D) 以上皆是。

請將答案填寫於對應的空格

高齡駕駛者的交通違規行為：參與短期教育課程前後變化與認知功能之相關性探討				
1	2	3	4	5

1. 有關高齡駕駛人之敘述，下列何者正確？
   (A) 根據日本警察署報告指出，75 歲以上的高齡駕駛人造成死亡事故的件數高於 75 歲以下的高齡駕駛人。
   (B) 在台灣並沒有相關研究顯示，高齡駕駛人與交通事故的件數有相關性。
   (C) 在台灣，無論駕駛人年齡，駕駛執照的有效期限都是一樣的。
   (D) 在日本，會針對 65 歲以上申請駕駛執照更新的駕駛人，進行認知功能評估
2. 有關本研究的敘述，下列何者不正確？
   (A) 本研究中探討高齡駕駛人的認知功能評估結果和交通違規行為之間的關係。
   (B) 本研究旨在驗證短期安全駕駛教育對高齡駕駛人的影響
   (C) 本研究使用駕駛模擬儀所收集的影像數據和全球定位系統所得到數字結果來設計短期 安全駕駛教育課程。
   (D) 本研究比較高齡駕駛人參加短期安全駕駛教育課程前後的差異
3. 下列哪一項不是本研究所使用的認知評估工具？
   (A) Trail Making Test (TMT)
   (B) Alzheimer's Disease Assessment Scale-Cognitive component-Japanese version (ADAS-Cog-J)
   (C) Rey-Osterrieth Complex Figure Test (ROCFT)
   (D) Montreal Cognitive Assessment (MoCA)
4. 有關本研究之結果，行車記錄器所觀察到的高齡駕駛人平均件數最多的三種交通違規行為，下列何者不是？
   (A) 違反停車再開標誌
   (B) 超速
   (C) 交叉路口不適當的左轉或右轉
   (D) 忽視交通信號
5. 有關本研究之結果，何者不正確？
   (A) 「交叉路口不適當右轉或左轉」與日本警察署高齡駕駛人認知功能評估測驗的「總分」之間有顯著相關性。
   (B) 「交叉路口不適當右轉或左轉」與日本警察署高齡駕駛人認知功能評估測驗的「時間方向得分」之間有顯著相關性。
   (C) 「超速」與日本警察署高齡駕駛人認知功能評估測驗的「延遲記憶得分」之間有顯著相關性。
   (D) 參加短期安全駕駛教育課程前後差異比較結果顯示，高齡駕駛人的交通違規次數有顯著差異。

39 卷第二期 通訊課程測驗答案

感覺處理功能障礙與自閉症青少年生活品質之關係				
1	2	3	4	5
C	B	C	A	A

以深度學習分析摺紙照片推估 3-6 歲兒童年齡				
1	2	3	4	5
D	C	B	A	C

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Original article

Influence of Direction and Surface Type on the Quality of Independent Wheelchair Transfer Technique

Alicia M. Koontz[a,b,c,*], Lin Wei[a,b], Theresa Crytzer[a,b]

Abstract

Objective: The purpose of this study was to determine the influence of surface type (commode and level bench) and the direction of transfer (moving to and from a wheelchair) on the quality of wheelchair transfer technique and to investigate if personal characteristics such as body weight, age, and disability type are related to technique differences between the surfaces and direction of transfer.

Design: Seventy-three men and 11 women performed transfers to and from their own wheelchair to bench and commode surfaces while the quality of their technique was scored using Transfer Assessment Instrument (TAI) version 3.0.

Results: Based on the TAI, participants used better technique when transferring to and from the commode seat than when moving to and from the bench (p=0.003). Better technique was used when transferring from the wheelchair to either surface than when transferring back to the wheelchair from either surface (p=0.007). Power wheelchair users and those who performed fewer numbers of transfers in their daily life tended to use incorrect leading arm hand placement during transfers (p<0.01).

Conclusion: A more challenging or restricted transfer surface may force wheelchair users to concentrate on transfer technique more. Poorer technique however was found while transferring back to the wheelchair. The results provide insight into the types of wheelchair users and transfers where greater emphasis on training proper technique should be placed.

Keywords: *Activities of Daily Living, Bathroom Equipment, Toilet Facilities, Upper Extremity*

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1. Introduction

In the United States, there were approximately 294,000 persons with spinal cord injury (SCI) in 2020, and 17,810 new cases occur each year (Facts and Figures at a Glance, 2020). Wheelchair users rely heavily on their upper extremities to perform certain essential activities of daily living (ADLs) such as wheelchair propulsion, transfers and weight relief maneuvers. The loading on the upper extremity joints during transfers is higher than any other wheelchair related activity (Gagnon, Nadeau, Noreau, et al., 2008). High forces and repetitive moments imparted on the upper extremities can lead to pain and injuries to the shoulder, elbow and wrist (Curtis et al., 1995; Dalyan et al., 1999; Dyson-Hudson & Kirshblum, 2004; Gagnon, Nadeau, Desjardins, et al., 2008; Gellman et al., 1988; Nichols et al., 1979; Paralyzed Veterans of America Consortium for Spinal Cord, 2005). The onset of pain and injury can be detrimental to wheelchair users resulting in decreased independence when conducting ADLs and reduced community participation (Dalyan et al., 1999; Mortenson et al., 2012).

Using proper transfer technique can reduce the loading on the upper arm joints and help protect wheelchair users from developing injury and pain (Tsai et al., 2014; Tsai et al., 2016). Proper transfer technique has been defined as setting up the wheelchair at a certain angle and distance away from the surface, bringing the body close to the edge of the surface prior to transfer, placing the leading and trailing arms in places and positions that minimize shoulder impingement and wrist extension, placing both feet on the floor, using a headhips motion during the lift phase and controlling the body's descent onto the target surface (Paralyzed Veterans of America Consortium for Spinal Cord, 2005; Tsai et al., 2013). A reliable and valid clinical tool incorporating these principles was developed called the Transfer Assessment Instrument (TAI) to aid in objectively evaluating the quality of independent transfer technique. Higher scores on the instrument have been correlated to better transfer biomechanics (e.g. lower joint forces and joint moments imparted on the upper extremities) (Tsai et al., 2014).

A full-time wheelchair user will perform on average 14 to 18 transfers per day (Finley et al., 2005). These transfers can occur to and from a wheelchair to a variety of surfaces over the course of a day (e.g. commode seats, car seats, couches, bed, floor, etc.). Certain surface characteristics such as the relative height of the surface with respect to the wheelchair (Wei, 2015), the amount of space available on and next to the surface (Tsai et al., 2018), and the presence/absence of handholds (Koontz et al., 2019) can influence the mechanical demands required for the transfer, the biomechanics involved and quality of the techniques used. For example, compared to transfers to level surfaces, transfers to higher surfaces are known to require greater upper extremity muscular effort and higher joint forces (Kulich, 2015). A descriptive study on car transfers found that the strategies for hand placement varied based on vehicle seat height and that individuals who placed their leading hands on the steering wheel had more shoulder pain than those who placed their hands on the drivers' seat or overhead on the grab bar or doorframe (Haubert et al., 2015). The amount and configuration of the space around toilets in a bathroom has been shown to alter the biomechanics and the quality of toilet transfers as measured using the TAI (Tsai et al., 2018). Another study showed that transfer quality as measured by the TAI was improved when transferring to a surface equipped with grab bars and a backrest compared to transferring to a surface without these elements (Koontz et al., 2019).

Most studies on transfers have described the biomechanics and quality of the transfer in one direction such as from the wheelchair to a platform, bench, commode or vehicle seat (Koontz et al., 2011; Tsai et al., 2014) or transfers between two platform surfaces (Finley et al., 2005; Gagnon, Nadeau, Noreau, et al., 2008). Less is known about the quality of the transfer back to the wheelchair and how that might differ from a wheelchair to surface transfer. Although transfers are variable over the course of the day (e.g. commode, bed, car, etc.), they all entail returning back to the wheelchair, and thus, transferring to a wheelchair is more commonly performed than any other type of transfer. The biomechanics of the transfer back to the wheelchair has been investigated in two studies (Forslund et al., 2007; Wei, 2015). In both of these studies trailing (push-off) side forces and moments across the shoulder, elbow and wrist (Wei, 2015) and forces at the hand (Forslund et al., 2007) were all higher for the transfer back to the wheelchair than the transfer from the wheelchair to the level bench (Wei, 2015) or mat table (Forslund et al., 2007). The reasons for these differences are not fully understood. The TAI evaluates the transfer technique by reviewing multiple components within the transfer and could provide direct clinical insight into specific aspects of the technique that may lead to higher forces when transferring back into the wheelchair.

The purpose of the study was to investigate and compare the quality of transfer techniques used to transfer to and from a wheelchair to a level-height bench (LB) and a commode seat (CM). The level-height bench was chosen to simulate a simple common surface that would be at the same height as the wheelchair seat and therefore less difficult to transfer to/from. A commode seat was chosen in contrast to simulate a more complex transfer with regards to limited space where the wheelchair can be placed or oriented and surface area size, shape and height (e.g. public standard commode seats in the United States are lower than the average wheelchair user's seat height and thus impose a non-level transfer for most people (Tsai et al., 2018)). It was hypothesized that 1) participants would have better technique (higher TAI scores) when moving between the wheelchair and LB than when moving between the wheelchair and CM and 2) better technique when moving from the wheelchair to level bench and commode than when moving from either surface back to the wheelchair. A secondary goal of the study was to describe the success rates (e.g. percentage of persons performing proper technique) in TAI item scores for all the transfers and to explore associations between sociodemographic characteristics (e.g. age, disability type, gender, etc.) and transfer skill deficits.

2. Methods

2.1 Participants

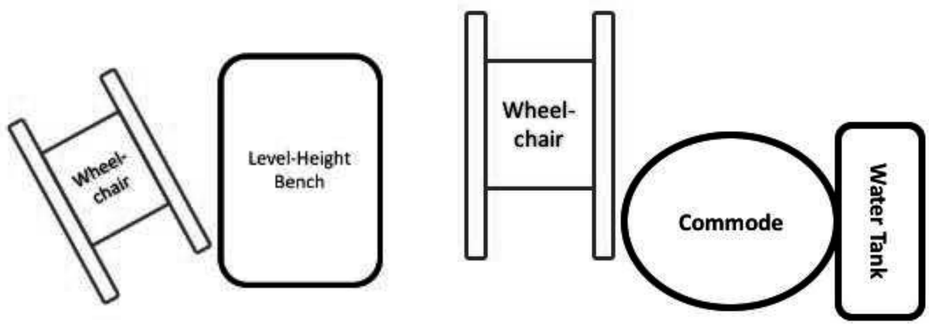
The study was approved by the Department of Veterans Affairs Institutional Review Board. Testing was conducted at the National Disabled Veterans Winter

Sports Clinic (NDVWSC) in Snowmass, CO, April 2016, the 36th National Veterans Wheelchair Games (NVWG) in Salt Lake City, UT, July 2016, and Human Research Engineering Laboratories (HERL) in Pittsburgh, PA. The inclusion criteria of the participants were (1) older than 18 years old, (2) one year after injury or diagnosis, (3) use a wheelchair for at least 35 hours/week, and (4) unable to stand up without support. Wheelchair users were excluded from the study if they had pressure ulcers within the last year or had a history of angina or seizures.

2.2 Testing Protocol

The position of the wheelchair, level-height bench, and commode are shown in Figure 1. The length and width of the bench were 70 cm x 55 cm. The overall length and width of the commode seat was 40 cm x 35 cm, the height of the seat was 45 cm. Both the bench and commode were placed on the participants' left-hand side due to constraints in the laboratory space and fastened to the ground before the trials. The height of the bench was adjusted to match the height level of the participant's wheelchair seat. Before starting the transfer trials, demographic information such as age, height, weight, and years using a wheelchair were collected for each participant. The order of the bench and commode surfaces were randomized for every participant. For the level-bench transfers, the participants were asked to position their wheelchair as they normally would before the transfer, and then asked to transfer to and from the bench in their habitual way. For the commode trials, the wheelchair approach angle was standardized based on the ADA guidelines ("Americans with

Disabilities Act (ADA) accessibility guidelines for buildings and facilities; play areas. Architectural and Transportation Barriers Compliance Board. Final rule," 2000). The orientation of the commode seat faced toward the wheelchair user (Figure 1) however they were free to locate their wheelchair at any distance away from the commode. Participants were required to land with their buttocks centered on the bench or on the commode seat and to place hands in their lap or at their sides before moving back to the wheelchair. They were given a chance to familiarize themselves with each setup prior to being asked to transfer. The participants were asked to transfer from and to their wheelchairs five times for each surface (i.e., bench, commode). The transfers to/from the bench/commode were scored using TAI version 3.0 by two trained raters who were blinded to the outcomes of the study.



(a) (b)

Figure 1

Level-height bench (a) and commode (b) set up.

2.3 Transfer Assessment Instrument (TAI) version 3.0

The TAI has acceptable to high inter- and intra- rater reliability intra-class correlation coefficient values ranging from 0.72 to 0.88 and good face, content, and construct validity (McClure et al., 2011; Tsai et al., 2013). The TAI 3.0 is a two-part assessment, with the first part consisting of specific transfer issues rated on a “yes”, “no”, or “not applicable” scale. Part 2 consists of global performance of transfer quality, techniques and indication of assistance, which is scored from 0 to 4. Because part 2 involves some of the same transfer skills that are measured in part 1, only part 1 of TAI was analyzed in this study as others before us have done (Hogaboom, Diehl, et al., 2016; Hogaboom, Huang, et al., 2016; Hogaboom, Worobey, et al., 2016; Tsai et al., 2016; Tsai et al., 2013). The Part 1 of the TAI contains 15 items that comprise individual components of a transfer. Item 2 “The angle between the participant’s wheelchair and the surface to which he is transferring is approximately 20-45 degrees” was not scored for the CM transfers. Item 5 “the participant performs a level or downhill transfer, whenever possible” was also excluded in this study. After watching all five transfers to and from a surface (bench or commode) the raters assigned one score to each item (‘yes’ or ‘no’) for each direction of transfer (wheelchair to surface and surface to wheelchair). The participant needed to perform proper technique on at least three of the five transfers to score a ‘yes’ on each item. After the raters independently scored the transfers, they compared their results to ensure consistency and consensus in the final scores.

2.4 Data Analysis

Descriptive statistics (means, standard deviations, ratios) were calculated for the demographic data. To compute the total TAI score, each item is first assigned a numerical value of 1 for a ‘yes’ outcome or a 0 for a ‘no’ outcome.

"Not applicable" items are removed from the dataset. The Part 1 score is the summation of all the applicable final item scores, multiplied by 10 and divided by the total number of applicable items. The total Part 1 score ranges from 0 (worst) to 10 (best).

A two-way repeated measures analysis of variance (ANOVA) was used to compare the TAI total scores between surface type (bench or commode) and direction of transfer: wheelchair (WC) to surface and surface to WC. Individual items were further examined by separating participants into two groups (proper and improper technique) based on their TAI item scores (yes and no) for each type and direction of transfer (wheelchair to bench, bench to wheelchair, wheelchair to commode and commode to wheelchair). The counts and percentages of the participants in the proper group to the total number of the applicable participants were calculated and compared using chi-square tests. Finally, we aimed to explore associations between sociodemographic characteristics and the transfer skills deficits. Categories were formed for each demographic variable, including: age (< 40 yr, ≥ 40 but < 60 yr, and ≥ 60 yr of age), gender (male and female), hand dominance (left and right), time since injury or diagnosis (10 yrs or less, > 10 but ≤ 20 yr, and > 20 yr), hours sitting in wheelchair per day (≤ 12 hr and > 12 hr), wheelchair types (manual wheelchair, power wheelchair, and scooter), total transfers per day (≤ 16 and > 16); body weight (< 78 kg and ≥ 78 kg); body mass index (BMI) (< 25 and ≥ 25 kg/m2), type of disability (tetraplegia, high paraplegia [thoracic 1 to 7], low paraplegia [thoracic 8 to lumbar 4]; and others). The associations between these groupings and TAI item scores ('yes' or 'no') were compared using chi-square tests for each type and direction of transfer (e.g. wheelchair to bench, bench to wheelchair, wheelchair to commode and commode to wheelchair). Fisher's exact test was applied if there were zero values in the cell count. The α value for these analyses was set at 0.05. If the test was significant and there were more than two subgroups in a category, such as age and time since injury or diagnosis, additional chi-square tests with a Bonferonni correction for the p-value were used to determine the specific subgroups that were significantly different from each other. The α value for the post hoc tests for age, time since injury or diagnosis, and wheelchair type was set at 0.017 (0.05/3), and 0.0125 (0.05/4) for type of disability. All the statistical analyses were performed in SPSS 25 (SPSS Inc., Chicago, IL).

3. Results

3.1 Participants

Twenty-seven participants at HERL, 31 participants at the NDVWSC, and 26 participants at the NVWG, volunteered for the study. Table 1 shows the demographic data of the participants. The sample consisted of mostly male Veterans (86.9%) using manual wheelchairs (86.9%).

The participants used their wheelchairs for average of 16.6 years and performed 19 transfers per day. All 84 participants completed the bench transfers. There were 9 subjects who did not complete the commode transfers because they did not perform commode transfers in daily living or felt it would be too difficult or unsafe.

Table 1
Demographic data (*N*=84)

Item		Mean (*SD*)	*n* (%)
Age		48.96 (12.27)	
Weight (kg)		79.52 (19.17)	
Height (cm)		173.37 (14.73)	
BMI (kg/m^2)		26.59 (6.90)	
Years after diagnosis		17.30 (9.99)	
Years using wheelchair		16.31 (10.27)	
Hours sitting in wheelchair per day		12.33 (4.00)	
Number of level height transfers per day		11.88 (7.50)	
Number of non-level height transfers per day		7.08 (5.19)	
Total transfers per day		18.80 (10.73)	
Wheelchair type	Manual		73 (87%)
	Power		9 (11%)
	Scooter		2 (2%)
Gender	Male		73 (87%)
	Female		11 (13%)
Handedness	Right		73 (87%)
	Left		10 (12%)
	Ambidextrous		1 (1%)
Ethnic	African American		28 (33%)
	Caucasian		43 (51%)
	Hispanic		8 (10%)
	Other*		2 (2%)
	Did not report		3 (4%)
Type of disability	Tetraplegia		16 (19%)
	High Paraplegia (T1-T7)		18 (21%)
	Low Paraplegia (T8-L4)		26 (31%)
	Transfemoral amputation		10 (12%)
	Others$		14 (17%)

*: Asian and mixed;

$: included Guillain-Barre syndrome (*n*=1), osteogenesis imperfecta (*n*=1), muscular dystrophy (*n*=1), myelopathy (*n*=1), multiple sclerosis (*n*=5), spinal bifida (*n*=1), and subjects did not report (*n*=4).

3.2 Effects of Transfer Direction and Surface on TAI Part 1 Total Scores

There were main effect differences in the Part 1 total scores for both surface type and direction of transfer (Table 2). Participants received higher total scores for the CM versus LB transfers (p=0.003) and when transferring to these surfaces from their wheelchair compared to when transferring back from these surfaces to their wheelchair (p=0.007). There was no interaction effect between direction of transfer (to or from the wheelchair) and surface (LB or CM) (p = 0.4).

3.3 Specific Deficits in Transfer Technique for each Direction and Surface

When transferring back to their wheelchair participants received lower TAI scores than when transferring to the LB and CM surfaces for item 6 “places feet in a stable position before the transfer”, item 7 “scoots to the front edge of the wheelchair seat before the transfer”, item 9 “A handgrip is utilized correctly by the leading arm”, item 10 “A handgrip is utilized correctly by the trailing arm”, and item 14 “The landing phase of the transfer is smooth and well controlled” (Table 3). Participants’ had higher scores on the handgrip positioning items 9 and 10 for the CM transfers than the LB transfers in both directions (Table 3).

Table 2
Main and interaction effects of TAI part 1 total scores for each surface and direction (N=75).

	Mean (*SD*)	Main effect (p-value)	Interaction effect (p-value)
Surface		0.003	
Level-height bench	7.24 (0.19)		
Commode	7.71 (0.15)		
Direction		0.007	
WC-S	7.61 (0.16)		
S-WC	7.33 (0.16)		
Surface × Direction			0.4

WC-S: transfer from wheelchair to the surface;
S-WC: transfer from the surface to the wheelchair.

Table 3
Comparison of the TAI item scores between both directions and surfaces. The percentages are the number of the participants who performed the item correctly relative to the total number of participants (*n*) for each applicable item.

TAI item description	Surface Type	*n*	Direction	
			WC-S *n* (%)	S-WC *n* (%)
1. The subject's wheelchair is within 3 inches of the object to which he is transferring on to	LB	84	54(64)	54(64)
	CM	75	47(63)	47(63)
2. The angle between the subject's wheelchair and the surface to which he is transferring is approximately 20-45 degrees	LB	83	58(70)	58(70)
	CM	N/A		
3. The subject attempts to position his chair to perform the transfer forward of the rear wheel (i.e., subject does not transfer over the rear wheel).	LB	74	55(74)	46(62)
	CM	67	55(82)	46(69)
4. If possible, the subject removes his armrest or attempts to take it out of the way	LB	43	26(60)	25(58)
	CM	39	19(49)	18(46)
5. The subject places his feet in a stable position (on the floor if possible) before the transfer	LB	77	49(64)	52(68)#
	CM	69	50(72)	57(83)#
6. The subject scoots to the front edge of the wheelchair seat before he transfers (i.e., moves his buttocks to the front 2/3rds of the seat).	LB	84	65(77)*	54(64)*
	CM	75	62(83)*	49(65)*
7. Hands are in a stable position prior to the start of the transfer.	LB	84	73(87)	74(88)
	CM	74	62(84)	59(80)
8. A handgrip is utilized correctly by the leading arm. (when the handgrip is in the individual's base of support)	LB	84	45(54)*,##	58(69)*
	CM	75	73(97)**,##	48(64)**
9. A handgrip is utilized correctly by the trailing arm. (when the handgrip is in the individual's base of support)	LB	84	49(58)	36(43)##
	CM	75	46(61)**	70(93)**,##
10. Flight is well controlled	LB	84	81(96)	82(98)
	CM	75	74(99)	73(97)
11. Head-hip relationship is used	LB	84	43(51)	47(56)
	CM	75	39(52)	45(60)
12. The lead arm is correctly positioned (The arm should NOT be extremely internally rotated and should be abducted 30-45 deg.)	LB	84	68(81)	71(85)
	CM	74	67(91)	67(91)
13. The landing phase of the transfer is smooth and well controlled.	LB	84	76(90)	69(82)
	CM	75	70(93)*	61(81)*

LB: Level-height bench; CM: commode; WC-S: transfer from wheelchair to the surface; S-WC: transfer from the surface to the wheelchair.
Statistically significant differences in each item between WC-S and S-WC are denoted as *p<0.05, **p<0.001, and between LB and CM are denoted as #p<0.05, ##p<0.001.

3.4 Relationship Between Participants' Characteristics and Transfer Skills

Power wheelchair users and wheelchair users who performed less than 16 (median from all participants) transfers per day were more likely to apply the wrong type of handgrip during the bench to wheelchair transfer (item 9) (Table 4). No other statistically significant differences in TAI scores across the various demographic variables and categories were found.

Table 4

Number (%) of the wheelchair users with certain demographic characteristics who performed Item 9 correctly and incorrectly.

Item 9 Transfer from bench to wheelchair	Improper technique		Proper technique		Statistics
	n	%	*n*	%	
Wheelchair Type					
Manual wheelchair	20	27	53	73	
Power wheelchair	6	67	3	33	
Scooter	0	0	2	100	
$\chi^2_{(2)}$					5.8
p-value					0.033
post hoc p-value, power wheelchair vs others					0.0142
Total transfers per day					
0 – 16	20	43	27	57	
>16	6	16	31	84	
$\chi^2_{(1)}$					6.719
p-value					0.008

4. Discussion

Most studies prior to this one have focused on describing the techniques associated with moving out of the wheelchair to other surfaces. The differences found in this study underscore the importance of also considering the return transfer back to the wheelchair and variations in techniques associated with CM versus bench transfers. Theoretically, the CM transfer was thought to be a more challenging transfer than the LB transfer due to a more limited surface area for landing, more limited places to position the leading and trailing hands, the 90 degree fixed wheelchair approach angle (ideal is 25-45 degrees), and non-level transfer since standard commode seats (e.g. which range between 43.2 to 48.3 cm) are lower relative the average wheelchair users' seat height (53.3 cm) (Toro et al., 2013). Rather it seems that this particular setup may have aided wheelchair users in performing better technique. The limitations of the setup likely limited the degrees of freedom or choice in movement strategies they could use to be successful with the transfer and fortunately these movement strategies were in favor of the TAI principles for proper technique. It was also noted that participants took longer when performing the CM transfer perhaps because the commode seat was smaller and more awkward in size and shape compared to the bench and lower that the wheelchair seat for most users. Thus, it is possible that the limitations of the setup may have forced people to think about their technique more and how to move more efficiently or accurately. This result aligns with a previous study that also found that environmental restrictions can have a positive influence on transfer techniques (Tsai et al., 2018). While our first hypothesis was rejected, the second hypothesis that transfer technique may be worse for transfers back to the wheelchair was supported by the results. Participants had higher average TAI total scores for the wheelchair-to-surface (WC-S) transfers than their surface-to-wheelchair (S-WC) transfers. This is also consistent with previous biomechanics studies that found higher forces were present when transferring back to the wheelchair from other surfaces (Forslund et al., 2007; Wei, 2015). The TAI item scores shed insight into the specific aspects of technique that may contribute to higher forces at the wheelchair side and between surfaces.

4.1 Item Analysis – Handgrip (Item 9 and 10)

Most participants (> 93%) performed proper handgrip at the commode side (Table 3, item 9 and 10). Proper handgrip technique occurs when the participant places their hand within his/her base of support and grips around the edge of a surface during the transfer as opposed to using a flattened hand or fisted hand on the surface to lift his/her body. During the LB transfer, some participants received a “No” on items 9 and 10 because they used an improper handgrip on the bench wherein they used a flat or fisted hand. Not many participants used a fisted hand on the commode seat possibly because the seat was a hard surface with a smaller surface area in comparison to the bench which was a cushioned surface with a larger contact area.

Item 9, leading handgrip for the transfer from the bench to the wheelchair, was the only item that was found to have group differences with regards to participant characteristics. This is different from previous work that found age, gender, and disability type were related to several TAI Part 1 item outcomes (Koontz et al., 2016). The absence of finding more group differences in this study could be related to the smaller numbers of women in our sample (73 men and 11 women) compared to the other study (74 men and 18 women) and distribution of disability types (e.g. 71% SCI in this study compared to 87% SCI in the other study) however mean ages and distributions were similar. The other differences could be attributable to an all Veteran cohort in the other study versus a mix of Veterans and non-Veterans in this study. The all Veteran cohort study (Koontz et al., 2016) found similar total TAI scores as our study for the wheelchair to bench transfer which was the only type and direction of transfer analyzed in the study but the percentage of items performed correctly or incorrectly varies across studies. For example only 50% of participants in the all Veteran study setup the angle of their wheelchair correctly versus 70% in this study. Thus the statistical relationship between certain socio-demographic factors and TAI outcomes may be influenced by the particular cohort studied and distribution of item responses.

Our study found that a higher percentage of power wheelchair users used improper handgrips when they transferred from the bench to their wheelchairs when compared to manual wheelchair and scooter users. More specifically the power wheelchair users tended to use fisted hands placed on the cushion whereas manual wheelchair users tended to grab onto or around the wheelchair frame and reserved the sitting area on the cushion for landing. Unfortunately, most power wheelchairs do not have as many options to support a gripped hand compared to the design of most manual wheelchairs (e.g. open spaces around the tubing or frame). In addition the physical features (e.g. weight, stability) of the wheelchair might also influence the transfer. For example, there may be a greater demand for manual wheelchair users to hold the frame properly to prevent wheelchair shifting during the transfer due the deceased weight or stability of the device compared to power wheelchairs. It is important to consider that while the number of power wheelchair users in this study were very small relative the number of manual wheelchair users (e.g. 9 versus 73) two thirds of them (67% or 6 of 9) used improper technique highlighting a potential sub-group for targeting transfer training (e.g. power wheelchair users who perform independent sitting pivot transfers). Moreover, our results show wheelchair users who performed fewer than 16 transfers per day had higher deficits rates for handgrips. Thus greater experience with transfers may explain why some users were choosing better leading handgrips.

4.2 Item Analysis – Feet position (Item 6)

More participants placed their feet on the floor before they started the CM transfer compared to the LB transfer (Table 3, Item 6). Feet positioning on the floor is important for stabilizing the body during the lift phase of the transfer. It is possible that the restriction imposed on the wheelchair orientation to match ADA compliant public bathroom configuration (e.g. perpendicular to the commode) or other features (e.g. commode size/shape and hardness for landing/gripping and potential non-level height) could have required increased stabilization for this more challenging transfer. The easiest transfers to perform are those that are level with the wheelchair seat height. As soon as the surface varies in height (up or down) individuals can begin to experience difficulty with performing the transfer (Toro et al., 2013). Other aspects that affect transfer difficulty include limited space on and around the transfer area for positioning the wheelchair, presence of physical barriers around the surface (e.g. tank) and surface hardness/softness. Thus placing the feet on ground may be more necessary for the successful and safe execution of the commode transfer versus the level bench transfer. Another important aspect to note was that there were no grab bars in our commode setup and which are present in many public and private restrooms and bathrooms which forced people to utilize parts of the commode to place their hands (e.g seat or tank). However a majority of individuals who perform sitting pivot transfers can not or do not use them as ADA compliant grab bars are not in an ideal position for this type of transfer (Tsai et al., 2018). When they are used, shoulder moments are greatly increased (Tsai et al., 2018).

4.3 Item Analysis – Scooting forward (Item 7)

More participants scooted forward in the wheelchair seat before they transferred (WC-S) (Item 7). Compared to when they were on the LB and CM surface getting ready to transfer back to the wheelchair (S-WC). Scooting forward in the wheelchair seat is recommended to bring the body closer to the target surface and also to clear the real wheel (for manual wheelchair users). On the other surfaces however, the main purpose would be to get closer to the wheelchair prior to transfer if no other obstacles are present. Neither the bench or the commode presented an obvious obstacle to scooting forward thus this may be a transfer component that could be better emphasized in training for S-WC transfers.

4.4 Item Analysis –Landing phase (Item 14)

More individuals scored lower for landing technique on the wheelchair than for landing on the commode. It is possible that the softer landing surface and presence of a wheelchair seat back may have provided some sense of security allowing for greater freedom of movement while transfers onto the smaller harder commode seat allowed limited room for error with regards to landing. Not scooting forward on the surface side (see Item 7 above) could also have impacted the landing scores on the wheelchair side. There may also be obstacles on the wheelchair side that make it more challenging during the transfer back such as limited places for handgrips (e.g. noted above for power wheelchair users), clearing items that are not removable (e.g foot rests, armrests, postural supports, clothing guards, and rear wheels for manual wheelchair users) and overcoming any issues with wheelchair instability (e.g. if wheel locks are not available or working). Many of these items are modifiable and can be addressed with appropriate wheelchair maintenance, setup, and technique training.

4.5 Limitations

Fifty-seven participants (68%) were U.S. veterans participating in an organized sport and recreational event and were mostly male (87%). These individuals may have a more active lifestyle than other Veterans and/or non-Veterans who do not participate these same events. However, many studies have reported that the daily activity level of the Veterans who participate in these events is similar to that of community-living non-Veteran wheelchair users (Levy et al., 2010; Oyster et al., 2011; Sonenblum et al., 2012; Tolerico et al., 2007). Transfer technique also has no clear association with daily activity levels or muscle strength (Minkel JL, 2010). Our study included mostly manual wheelchair users and only a few power wheelchair and scooter users. For the TAI 3.0, there are no specific guidelines for scoring the items for scooter users. A newer version of TAI (version 4.0) is available that provides a slightly modified list of items and responses and more specific scoring for persons using scooters that should be considered for future studies (Worobey et al., 2018). This study was conducted by using the TAI 3.0 and before the latest version TAI 4.0 was published. The TAI 4.0 has improved in the graphical presentation and assessment details for each item statement. This version also includes scoring a transfer "to and from" a surface however data on the quality of transfer to and from different kinds of surfaces are not available yet. The TAI is a convenient tool for observing and quantifying transfer quality however it doesn't provide the same level of detail on movement strategies that can be obtained with a three-dimensional motion capture system. It would be interesting to conduct a follow up study using this type of system to investigate and describe the joint ranges of motions and any compensatory movement strategies that are being used between the two surfaces and directions.

5. Conclusion

Transfer technique was found to vary when transferring from/to a wheelchair and between different targeted surfaces. A more challenging or restricted transfer surface may force wheelchair users to concentrate on transfer technique more and make smarter choices in their movement strategies. Poorer technique however was found for transfers back to the wheelchair and may be related to how they positioned themselves on the surface prior to making the transfer and being unable to control the landing as well. The results support the importance of technique training especially for the return back to the wheelchair from other surfaces. Future studies are needed to determine the best strategies for teaching transfer technique and if focusing learning proper technique to and from less restricted surfaces (e.g. transfers to a mat table) can carry over to more challenging transfer surfaces. Moreover, factors related to the transfer techniques, such as anthropometric parameters (e.g. body size and weight), ergonomics, biomechanics, wheelchair design, furniture and environmental setting are also critical issues to be considered and investigated in the future.

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轉位方向與平面對於輪椅轉位技巧之影響性探討

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摘要

目的：探討不同輪椅轉位的平面與方向是否會影響輪椅轉位技術的品質，以及調查個人因素如體重、年紀及殘障類別是否與轉位技巧有關。

方法：共調查 73 男性與 11 位女性進行從自身的輪椅轉位到長板凳椅與便盆椅的轉位活動，採用轉位評估工具 3.0 版評估他們轉位的技巧。

結果：當轉位到便盆椅時，不論是轉位過去或轉位離開，受測者皆有較佳的轉位技巧，相對於轉位到長板凳椅（p=0.003）。當從自身輪椅離開轉位到其他的平面時，受測者亦皆有較佳的轉位技巧，相較於從其他平面轉回到自身輪椅(p=0.007)。電動輪椅使用者與轉位頻率較少者往往會傾向使用不正確的轉位引導手擺位進行轉位活動 (p<0.01)。

結論：本研究顯示更具挑戰性或受限制的轉位平面可迫使輪椅使用者更專注於轉位技巧使用；反而在轉位回到輪椅時則會出現較差的轉位技巧。本研究結果提供了對輪椅使用者和轉位類型的深入了解，其中應更加重視培訓適當的轉位技巧。

關鍵字：日常生活活動，衛浴設備，廁所設施，上肢

（附註：此中文摘要由客座編輯楊育昇教授翻譯撰寫）

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Original article

On-Road Driving Traffic Violations in Elderly Drivers: Its Relationship With Cognitive Function Tests and Changes After a Road Safety Course

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Abstract

Introduction: The aim of this study was to investigate the relationship between cognitive function and traffic violations, and to examine the change of traffic violations after a road safety course in elderly drivers.

Methods: We examined the relationship between cognitive function and driving behaviors of the elderly, and conducted a road safety course to estimate the effect of the course. The Spearman's rank correlation coefficient was computed to determine the correlations, and the Wilcoxon signed-rank test was used to compare traffic violations before and after the course. Cohen's guidelines of r = .10, .30, and .50 were used to interpret observed effect sizes as small, medium, and large, respectively.

Results: Twenty participants were included. Significant correlations were found between the improper right or left turn at an intersection with the total score (Spearman's *rho*=-.50, *p*=.024), orientation for time score (*rho*=.57, *p*=.009), and delayed recall score (*rho*=-.58, *p*=.010) of the Japanese National Policy Agency Cognitive Impairment Screening Test for Senior Drivers. A significant correlation was also found between speeding and delayed recall score (*rho*=.45, *p*=.048). However, the change of trafic violations after the road safety course was not significant.

Conclusion: Our results suggest that a single cognitive function test is not enough to detect unsafe driving. Future research is needed to clarify the effect of road safety course using video image data of driving in elderly drivers.

Keywords: *Cognitive Function, Driving Safety, Elderly Drivers, On-road, Traffic Violations*

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1. Introduction

Recently, fatal and serious traffic accidents caused by elderly drivers occur with increasing frequency in Japan. The Japanese government has pointed out that elderly drivers with reduced cognitive functions are at a higher risk of traffic accidents. According to the National Police Agency of Japan (2018a), the number of fatal accidents caused by elderly drivers aged 75 and above is higher than that of elderly drivers under the age of 75. The elderly driving issues have also been discussed in other countries. In Australia, research showed a slight increase in the involvement of drivers aged 85 and older in fatal crashes (Thompson et al., 2018). A report from Taiwan (Directorate General of Highways, n.d.) also indicated that the number of traffic accidents by elderly drivers aged 75 and over increased from 97 in 2012 to 103 in 2016.

To decrease traffic accidents in older drivers, some countries have revised policies. In Japan prior to 2017, cognitive function tests were conducted every three years for drivers over 75 years old when they applied for the driver's license renewal. However, the Japanese government revised the traffic law in 2017 in consideration of the fact that cognitive function in elderly people (especially those over 75 years old) may decline year by year (National Police Agency, 2021) and that there are individual differences in driving abilities (National Police Agency, 2017). The amendment includes that drivers over 75 years old who committed certain traffic violations would need to take cognitive function tests and those who are suspected for having dementia would need immediate medical consultations. A similar driving license policy also can be found in Taiwan. In 2017, the Taiwanese law on driver's license management system for the elderly came into effect (Directorate General of Highways, 2017). This law mandates the renewal of licenses every two years for motor vehicle and motorcycle drivers over the age of 75. In order to renew their driving licenses, they must pass the medical examination standards and cognitive function tests specified in the law.

The Japanese government recommends surrendering of driver's license in cases with dementia, possibility of dementia, and anxiety about driving. Local governments also encourage voluntary return of driver's license for the elderly. For example, elderly people who voluntarily return their driver's license can get coupons for public transportation. The number of voluntary return of driver's license in Japanese elderly people over 65 has increased year by year (National Police Agency, 2018b). However, the rate of elderly driver's license voluntary return is not always high. In Tokyo, where the public transportation system is well developed, the rate is 7.25%, but in Ibaraki Prefecture, where this study was carried out, it is 3.19% (NLI Research Institute, 2019). A significant difference was found between the urban city and suburban or rural area, and inadequate public transportation in suburban areas is the primary reason.

On the other hand, driving ability is related to quality of life in the elderly. A study reported that continuing to drive was strongly associated with reducing the amount of care provided to the elderly and preventing the decline of cognitive function (Shimada et al., 2016). It is necessary for the elderly in suburban areas to preserve independent mobility and activity.

Although there have been several approaches to decrease traffic accidents by elderly drivers, traffic accidents caused by this population is still an issue in Japan (National Public Safety Commission and National Police Agency, 2020). For the elderly who live in country areas and have to continue driving, we suggest it is important to re-educate them on how to drive safely.

The drive recorders were applied in the safe driving program in Japanese companies related to transportation or delivery business. The content of the program is to learn how to drive safely, prevent traffic accidents, and to improve risk prediction by watching video recordings. The safe driving program was reported to decrease the number of accidents from an average of 1.31 cases per month to 0.57 cases at 76 companies which carried out safe driving program using drive recorders (Japan Trucking Association, 2015).

Some studies have examined the relationship between cognitive function and performance in standardized road tests, and found that the elderly dementia group had worse driving performance and poorer cognitive function than the elderly without dementia (Carr et al., 2011; Aksan et al., 2015).

Driving skills include several continuous processes of recognition, judgment, and operation. In order to drive safely, the driver must be aware of the traffic and make accurate judgments. Drivers also maintain safe driving by a process of constant self-feedback and modification of driving maneuvers in response to various changing traffic conditions. Therefore, in this study, we hypothesized that attention function and spatial cognitive function would be related to oversights and mistakes regarding traffic lights and signs. Older adults with declined cognitive function would have more mistakes regarding traffic lights and signs while driving a car than older adults without cognitive decline.

Inconsistent results have been reported on the relationship between cognitive function and driving abilities. Therefore, the purpose of this study was to examine the relationship between the cognitive function assessments of elderly drivers and their traffic violations in daily life situations. In addition, we aimed to examine the effect of a short-term safe driving educational program for elderly drivers by using drive recorder video data and Global Positioning System (GPS) digital data.

2. Methods

2.1 Participants

Participants were recruited by free town newspapers that were distributed in 13 cities in the south of Ibaraki Prefecture, Japan. The inclusion criteria were: (1) age 65-80, (2) having a valid ordinary car driving license, (3) driving more than once a week, (4) having voluntary driving insurance, and (5) family approval for participation in this study. The family consent was obtained to allow the participant only to use his/her own car for two weeks (one week before and one week after the educational program). The participants also signed the informed consent.

The exclusion criteria were: (1) having any medical conditions making them inappropriate to drive (e.g., epilepsy, syncope), (2) the diagnosis of dementia from a doctor, or suspected as having cognitive impairments screened by the Mini-Mental State Examination (MMSE, Folstein et al., 1975; Mori et al., 1985) < 24, and (3) category 1 in the Cognitive Impairment Screening Test for Senior Drivers. This study has been approved by the Medicine Ethics Committee of Ibaraki Prefectural University of Health Sciences (approval number: 852).

2.2 Measurements

Figure 1 shows the flow chart of this study. The assessments included the MMSE, Cognitive Impairment Screening Test for Senior Drivers, Trail Making Test (TMT), Alzheimer's Disease Assessment Scale-Cognitive component-Japanese version (ADAS-Cog-J) maze task, and Rey–Osterrieth Complex Figure Test (ROCFT).

The Cognitive Impairment Screening Test for Senior Drivers is incorporated in the Japanese Road Traffic Act (National Police Agency, n.d.). The examination is required for license re-newers aged 75 and over as a screening test for dementia. The content of the test includes orientation for time, short term memory test, and clock drawing. The second part of the Screening Test is a delayed recall test of four sets of four graphic objects. The score was generated from participants' free recall and cued recall performance of the 16 items. An overall score was calculated from these subscale scores. The more correct answers, the higher overall score.

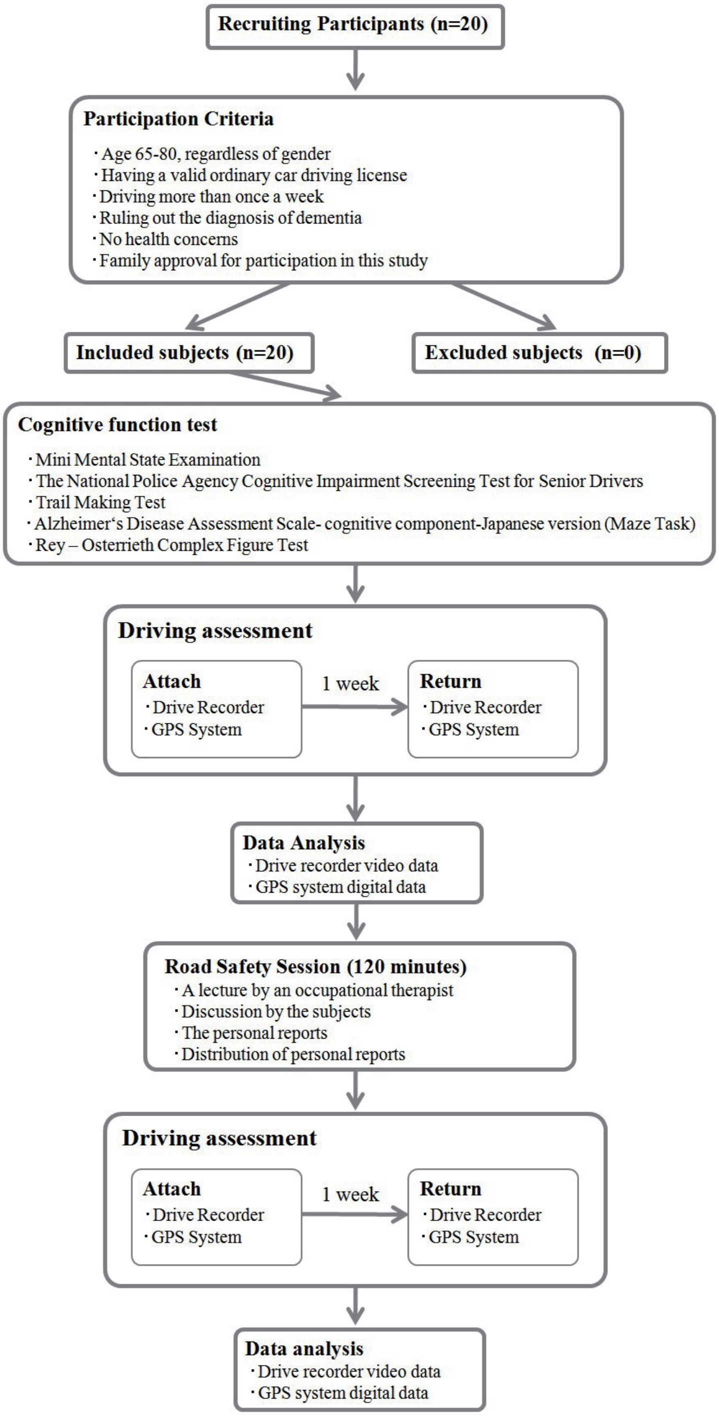

Figure 1. The research steps

According to that overall score, the participants were classified into three categories: (1) may have dementia (total score<49), (2) mild decline in cognitive function (total score between 49 and 75), and (3) no cognitive decline (total score>75).

The TMT was used to test attention function (Davies, 1968). Part-A is an inspection that connects numbers (1 to 25) with a line. The Japanese version of Part-B is a test that connects numbers (1 to 13) and hiragana characters (from 'あ' to'し') alternately with lines. In this study, the time required for each was measured using the vertical type of Part-A and Part-B. Non-completion within the cut-off time indicates decline of attentional function.

The ADAS-Cog was used to assess the progression of Alzheimer's disease and Mild Cognitive Impairment (Mohs et al., 1983). ADAS-Cog-J is the Japanese version of ADAS-Cog (Sugisita, 2011) and consists of 15 subtests. Among the subtests, we used the maze task and measured the required time and the number of errors.

The ROCFT evaluates the participant's visual (non-verbal) memory and visual space cognition. Participants were asked to copy a complex figure (copying task) and draw it again from memory three minutes later (delayed recall task). The maximum score for both tasks is 36 points (Anamizu, 2003). The more accurately the figure, the higher the score. The psychometric characteristics of the ROCFT have been studied (Liberman et al., 1994).

We also obtained driving behaviors by analyzing drive recorder video data, and GPS digital data. A drive recorder (DRV-830, manufactured by Kenwood Corporation) and GPS (manufactured by Genext) were installed in each participant's private car. The participants were asked to drive as usual for a week (seven days). The drive recorder and GPS were set to continuous recording mode during driving. The drive recorder with camera and body integrated was mounted within 20% of the top of the windshield or behind the rear-view mirror. The viewing angle of the camera was recorded at 132° horizontal, 70° vertical, and 144° diagonal in front. The drive recorder device had a built-in GPS and was used to log the exact position and speed of the participant's vehicle. At any point in the video recording, it allows us to pinpoint where it happened and how fast the vehicle was moving.

The video image data were downloaded from the drive recorder to examine driving behaviors. Eighteen types of traffic violations commonly made by older drivers with cognitive decline (National Police Agency, 2016) were examined. In addition, driving data (route, speed, distance and frequency of travel, duration of each trip) were collected from the GPS. In a GPS, satellites are used to automatically analyze the speed of the car (e.g., stopped, not stopped). This GPS was designed to support positioning using the Quasi-Zenith Satellite System (QZSS). The QZSS is a Japanese satellite navigation system developed by the Japan Aerospace Exploration Agency. The system supported sub-meter class positioning, which can measure the position with an error of less than one meter. Of these traffic violations observed in the GPS, digital data were automatically analyzed for the following violations per 1 kilometer: stop sign violation, driving between 0 to 19 km/h over the speed limit, driving between 20 to 25 km/h over the speed limit, and failure to stop at railroad crossings.

We synchronized the video data of the drive recorder with the digital data of the GPS. Moreover, we studied the data for seven days before and after the participants took the road safety course. We identified 18 different violations from the drive recorder and counted all the participants' traffic violations. From the GPS, we counted the number of automatically recorded driving distances, driving hours, failure-to-stop violation locations, speed limit violations, and failures to stop at railroad crossing violations.

2.3 Intervention

The road safety course, lasting 120 minutes, was supervised by a staff member of Ibaraki Police Headquarters and a staff member of Ibaraki Driver's License Center, Japan. The course first started with an occupational therapist giving a lecture on the characteristics of driving as seen from a drive recorder using slide teaching materials. Then the participants watched a video clip of six different dangerous driving scenes with multiple violations. After that, they were divided into two groups to discuss "what kind of danger may occur" and "what kind of driving behavior leads to safe driving". After their discussion, the researchers talked to the participants about the characteristics of traffic accidents caused by Japanese elderly drivers and provided personal reports to all participants. The report summarized the 7-day driving records based on the analysis of the drive recorder and GPS data, including the number of driving days, driving time, mileage, good points, refinement, and advice. We expected that the information in these reports could provide a useful reference for them to drive safely in the future. We also received advice on the content of the road safety course from the supervising police officers.

2.4 Data Analysis

Descriptive statistics was shown with mean and standard deviation. The percentage of traffic violations in the drive recorder video data and GPS digital data was calculated based on the average number of violations per kilometer of distance traveled by the participants over the seven days. The correlation between each test on the cognitive function and the number of traffic violations was analyzed using the Spearman's rank correlation coefficient. A Wilcoxon signed-rank test was used to compare the performance before and after the road safety course. The statistical analysis package software SPSS Statistics ver. 27.0 was used. The significance level of each test was set at 5% ($p<.05$). Effect size r as a measure of change before and after the course was calculated and interpreted according to the criteria by Cohen (1992) (small: .10; medium: .30; large: .50).

3. Results

3.1 Participant Characteristics and Number of Traffic Violations

Twenty elderly people participated in this study and the participant characteristics were shown in Table 1. Figure 2 shows the average number of traffic violations observed in the drive recorder videos. The most frequently occurring violations were stop sign violation (24.10 times), improper right or left turn at an intersection (13.55 times), and ignoring traffic signals (3.85 times). Figure 3 shows the average number of traffic violations observed in the GPS data. The most frequently occurring violations were driving between 0 to 19 km/hr over the speed limit (27.80 times), stop sign violation (14.15 times), and driving between 20 to 25 km/hr over the speed limit (4.50 times).

Table 1

Participant characteristics (*N*=20)

	Mean (*SD*)	*n* (%)
Age (years)	73.2 (4.3)	
Gender		
Men		10 (50%)
Women		10 (50%)
Holding a license (years)	44.2 (9.9)	
Traffic accidents withing the past 5 years		2 (10%)
Traffic violations within the past 5 years		5 (25%)
MMSE	29.05 (1.2)	
TMT–Part A (seconds)	33.1 (10.5)	
TMT–Part B (seconds)	102.9 (34.8)	
CIST-SD		
Category 2		6 (30%)
Category 3		14 (70%)
Total score	81.3 (7.8)	
Orientation for time	14.9 (0.4)	
Delayed recall score	22.7 (4.5)	
Clock drawing	7 (0)	
Maze task in ADAS-Cog-J		
Time (seconds)		
Number of errors	54.9 (31.7)	
ROCFT	2.5 (2.5)	
Copy	35.4 (1.1)	
3-min delayed recall	21.6 (6.5)	

Note. MMSE = Mini-Mental State Examination; TMT-A = Trail Making Test Part-A; TMT-B = Trail Making Test Part-B; CIST-SD = Cognitive Impairment Screening Test for Senior Drivers; ADAS-Cog-J = Alzheimer's Disease Assessment Scale-cognitive component-Japanese version; ROCFT = Rey-Osterriech complex figure Test.

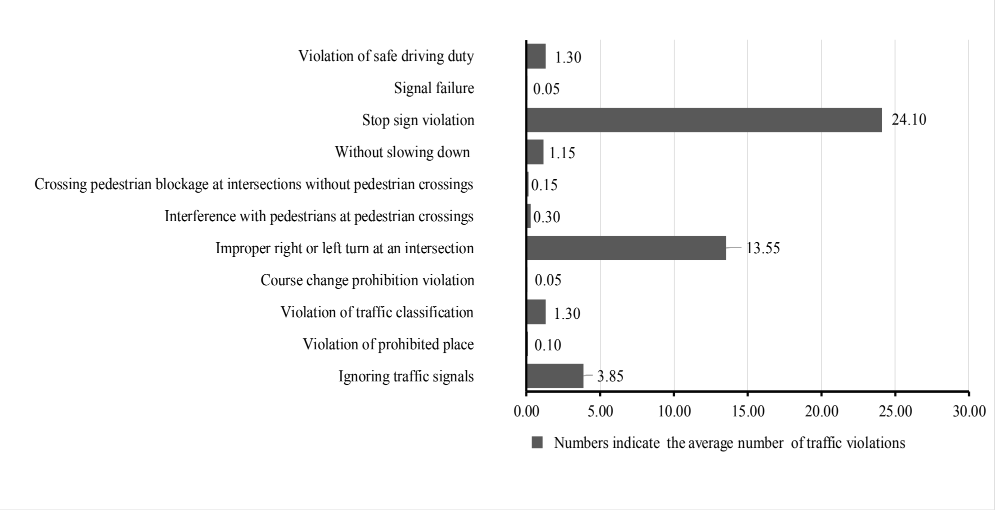

Figure 2

Average number of traffic violations observed in the drive recorder video (20 participants)

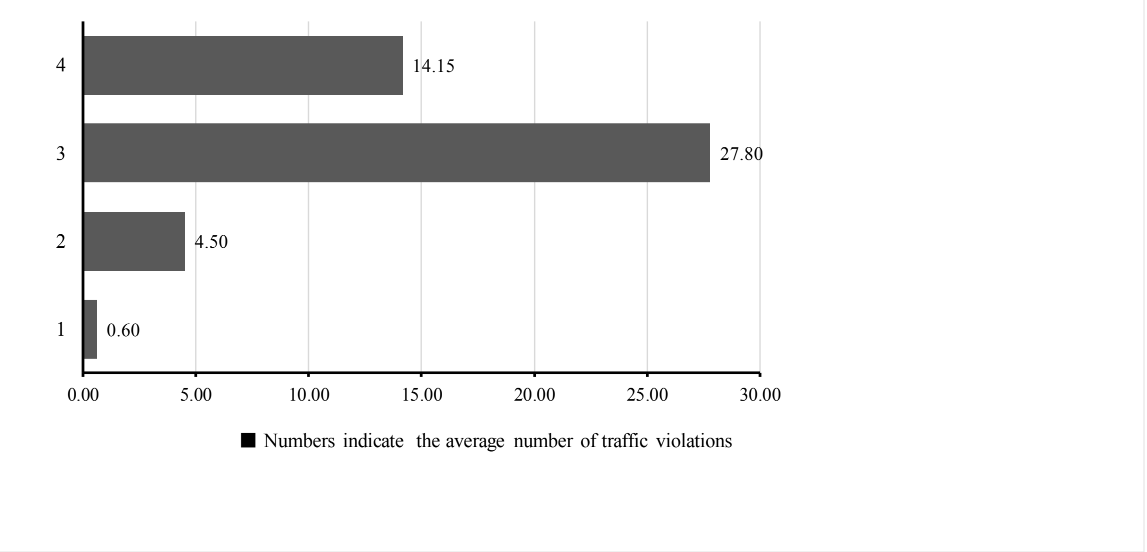

Figure 3

Average number of traffic violations observed in the GPS (20 participants)

3.2 Correlation Between Cognitive Functioning and Traffic Violations

Table 2 shows the correlation between cognitive functioning and traffic violations observed from the drive recorder videos. A significant correlation was shown between the stop sign violation and the orientation for time score of the Cognitive Impairment Screening Test for Senior Drivers (*rho*=.45). Significant correlations were also found between the improper right or left turn and the total score (*rho*=-.50), orientation for time score (*rho*=.57), delayed recall score (*rho*=-.58) of the Cognitive Impairment Screening Test for Senior Drivers. Additionally, marginally significant correlations were observed between the improper right or left turn and the ROCFT Copy score (*rho*=-.42), and between violation of ignoring traffic signals and TMT-B Time (*rho*=.40) and ROCFT Copy score (*rho*=-.39).

Table 3 shows the correlation between cognitive functioning and traffic violations recorded by the GPS. A significant correlation was found between driving 0 to 19 km/hr above the speed limit violation and delayed recall score in the Cognitive Impairment Screening Test for Senior Drivers (*rho*=-.45). Additionally, marginally significant correlations were seen between the stop sign violation and the orientation for time score of the Cognitive Impairment Screening Test for Senior Drivers (*rho*=.43) and the number of errors of maze task for ADAS-Cog-J (*rho*=.42).

Table 2

Correlation between cognitive functioning and traffic violations by drive recorder video data (*N*=20)

	Stop sign violation		Improper right or left turn at an intersection		Ignoring traffic signals	
	rho (ρ)	*p*-value	*rho* (ρ)	*p*-value	*rho* (ρ)	*p*-value
MMSE	.56	.814	- .15	.543	- .14	.545
TMT-A Time (seconds)	- .06	.806	- .03	.905	.10	.692
TMT-B Time (seconds)	.11	.640	.08	.748	.40	.081
CIST-SD						
Total score	.19	.431	- .50	.024*	- .36	.121
Orientation for time	.45	.047*	.57	.009***	.29	.212
Delayed recall score	.17	.474	- .58	.010**	- .35	.135
Maze task for ADAS-Cog-J						
Time (seconds)	.20	.932	.19	.421	.12	.622
Number of errors	.37	.106	.10	.681	.08	.732
ROCFT						
Copy	- .10	.677	- .42	.067	- .39	.090
3-min delayed recall	- .17	.465	- .15	.539	- .29	.221

Note. MMSE = Mini-Mental State Examination; TMT-A = Trail Making Test Part-A; TMT-B = Trail Making Test Part-B; CIST-SD = Cognitive Impairment Screening Test for Senior Drivers; ADAS-Cog-J = Alzheimer's Disease Assessment Scale-cognitive component-Japanese version; ROCFT = Rey-Osterriech complex figure Test.

*p < .05. **p<.01. ***p<.001.

3.3 Change After the Road Safety Course

Table 4 shows the traffic violations before and after the road safety course. For the drive recorder data, the differences were not significant and with medium effect sizes. For the GPS data, the differences were small and not significant.

Table 3 Correlation between cognitive functioning and traffic violations by drive recorder video data (*N*=20)

	Stop sign violation		Driving between 0 to 19 km/h over the speed limit		Driving between 20 to 25 km/h over the speed limit	
	rho (ρ)	*p*-value	*rho* (ρ)	*p*-value	*rho* (ρ)	*p*-value
MMSE	- .01	.983	.01	.967	- .06	.798
TMT-A Time (seconds)	- .03	.887	- .01	.970	.24	.305
TMT-B Time (seconds)	.10	.663	- .22	.349	.04	.883
CIST-SD						
Total score	.09	.719	- .40	.081	.01	.975
Orientation for time	.43	.062	.28	.233	.05	.837
Delayed recall score	.07	.776	- .45	.048*	- .05	.851
Maze task for ADAS-Cog-J						
Time (seconds)	.04	.875	.07	.757	.09	.702
Number of errors	.42	.062	- .14	.546	.08	.749
ROCFT						
Copy	- .15	.538	- .26	.269	.05	.824
3-min delayed recall	- .18	.449	- .10	.672	.09	.712

Note. MMSE = Mini-Mental State Examination; TMT-A = Trail Making Test Part-A; TMT-B = Trail Making Test Part-B; CIST-SD = Cognitive Impairment Screening Test for Senior Drivers; ADAS-Cog-J = Alzheimer's Disease Assessment Scale-cognitive component-Japanese version; ROCFT = Rey-Osterriech complex figure Test. *$p < .05$.

Table 4

Traffic violations before and after the road safety course (*N*=20)

	Before	After		
Traffic violations	Mean ± *SD* (range)	Mean ± *SD* (range)	*p*-value	Effect size
Driver recorder data				
Stop sign violation	0.21±0.09 (0.02-0.36)	0.17±0.11 (0.04-0.46)	.145	.33
Improper right or left turn at an intersection	0.15±0.11 (0.02-0.42)	0.11±0.08 (0.01-0.37)	.073	.40
Ignoring traffic signals	0.04±0.03 (0.00-0.09)	0.03±0.02 (0.00-0.09)	.117	.35
GPS data				
Stop sign violation	0.12±0.06 (0.03-0.22)	0.10±0.06 (0.01-0.22)	.255	.26
Driving between 0 to 19 km/h over the speed limit	0.25±0.17(0.00-0.64)	0.22±0.13(0.04-0.45)	.444	.17
Driving between 20 to 25 km/h over the speed limit	0.04±0.03 (0.00-0.13)	0.03±0.03 (0.00-0.11)	.334	.22

4. Discussion

For the elderly, driving as a means of transportation is important in maintaining quality of life. This study examined the relationship between cognitive function and traffic violations and the effects of a road safety course for elderly drivers. In this study, older adults with a diagnosis of dementia and suspected to have moderate to severe cognitive impairments or dementia were excluded. Therefore, the target population was active community-dwelling older drivers with normal cognitive function or mild cognitive impairment. Although one participant in our study had extreme scores, the results of statistical analyses were similar with and without that participant. Therefore, we decided to report the data of all 20 participants, and it is recognized that this is a small sample size and future research should include a larger sample size.

This study used a naturalistic driving observation approach and recorded older drivers' behavior over 14 days (in total). Our approach is different from Uc et al. (2005), who applied a way-finding task, and Grace et al. (2005), who administered a standardized on-road driving evaluation. The different approaches may lead to different driving performances (Chen, Gélinas, & Mazer, 2018). In our study, the videos from the drive recorders were visually checked. We detected violations that could cause serious traffic accidents to assess the characteristics of unsafe driving behavior of elderly drivers.

The types of violations that can be identified by the drive recorder videos and GPS digital data are different. In this study, the video recording had almost double the number of stop sign violations compared to the GPS recordings. This was because even with the GPS tracking the vehicle while it was in motion, it was not possible to detect all of the restricted areas. For example, on narrow or newly completed roads, a pause violation could go undetected. On the other hand, the video images of the drive recorder made it possible to observe such events in more detail. After checking the videos from the drive recorders, we found participants were not slowing down enough when making right and left turns at intersections. Some of the participants turned at intersections at speeds close to 40 km/h, and they were counted as having more right and left turn violations and steering wheel operation was executed before gas pedal or brake operation. This finding led us to believe that when sudden danger occurred, they would not decelerate sufficiently and would instead operate the steering wheel on the spur of the moment, leading to a major collision. In the future, we would like to obtain greater detail by analyzing video clips from drive recorders and compare their speed start time and steering wheel operation time.

It is important to evaluate older people's cognitive function to know if they can continue to drive safely or not. A number of studies have reported that a single cognitive test is inadequate to determine driving aptitude in older adults (Carr et al., 2011; Manning, Davis, Papandonatos, & Ott, 2014). The MMSE was reported to have moderate predictive validity for pass/fail on road driving assessments (Crizzle, Classen, Bédard, Lanford& Winter, 2012). The Montreal Cognitive Assessment (MoCA) was reported to have slightly higher predictive validity than the MMSE if the MoCA score was less than 18 (Hollis, Duncanson, Kapust, Xi, & O'Connor, 2015). Our study found that conducting a single dementia screening test, such as the MMSE, may not be able to adequately assess the risks and dangers of elderly drivers. To understand the relationship between cognitive function and dangerous driving behavior of elderly drivers, we investigated the relationship between cognitive function and common traffic violations. We found a significant correlation between the inappropriate turns at an intersection and the delayed recall test of the National Police Agency Cognitive Impairment Screening Test for Senior Drivers, which may be because drivers forgot the traffic environment they had recognized and thus made inappropriate turns. In addition, we found that ignoring traffic signals only had marginally significant correlations with the TMT-B and ROCFT Copy. A cohort study reported that the ROCFT and TMT-B were useful in distinguishing between safe and unsafe drivers in patients with Parkinson's disease and Alzheimer's disease (Grace et al., 2005). The reason for the different results may be related to the fact that the participants in this study were healthy elderly drivers, and the cognitive function assessments we used were not sensitive enough. Future work with sensitive measures for cognitive function in healthy elderly drivers is needed.

The results of this study showed that the road safety course tended to reduce the number of improper right and left turns at intersections and ignoring or missing traffic signals. Examining actual driving images from drive recorders can provide feedback to elderly drivers and enhance their safety awareness. Elderly drivers who are concerned about driving safety are likely to have high motivation to attend the road safety course, while drivers who are not confident in their driving ability may not. Future research should encourage elderly drivers who are anxious about driving to participate.

5. Conclusion

We analyzed drive recorder data and GPS digital data to understand traffic violations commonly made by elderly drivers, and then investigated the relationship between cognitive functional tests and traffic violations and conducted a road safety course for elderly drivers. The results only showed a few significant associations between some cognitive function tests and traffic violations. The participants had marginally significant decrease in improper turns at intersections after the road safety course. This study highlights the importance of realistic assessments using drive recorders and GPS information. Future research is needed with a large sample size and including elderly drivers who are less confident in driving.

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原著

高齡駕駛者之交通違規行為：與認知功能之相關及參與道路安全課程前後之變化

福澤恵 [1,*]　白石英樹 [2]　董玟伶 [2]　Neil David Parry[3]

摘要

背景：本研究旨在調查認知功能與交通違規行為之間的關係，並檢驗短期駕駛教育課程對高齡駕駛者安全駕駛的效應。

方法：本研究首先評估高齡受測者的認知功能和駕駛行為，並根據評估結果，舉辦道路安全駕駛課程及評估此教育課程的成效；此外亦探討高齡駕駛者認知功能和交通違規行為之間的相關性。研究統計採用斯皮爾曼等級相關係數 (Spearman's rank correlation) 來分析各變項的相關性，威爾卡森符號檢定 (Wilcoxon signed rank test) 用於檢驗短期安全駕駛教育的效果，使用 Cohen's *r* 來評估效果大小，*r* 值 .10、.30、.50，分別代表效果小、中、大。

結果：共有 20 名高齡者參與本研究。受測者駕駛違規行為中，「交叉路口不適當右轉或左轉」與日本警察署高齡駕駛人認知功能評估測驗之「總分」(*rho*=- .50, *p*= .024)、「時間方向得分」 (*rho*= .57, *p*= .009)、「延遲記憶得分」之間有顯著相關性 (*rho*=- .58, *p*= .010)。另外「超速」和評估測驗中的「延遲記憶得分」之間也有顯著相關性 (*rho*= .45, *p*= .048)。然而，短期安全駕駛教育的前後測差異未達統計學上顯著意義 (*p*=.073，*r*= .40)。

結論：本研究結果建議單一的認知功能測試不足以評估駕駛安全性。未來研究仍需要對高齡駕駛者進行更深入的調查，並確認利用其駕駛影像資料進行短期安全駕駛教育的效果。

關鍵字：高齡駕駛者，駕駛安全，行車，認知功能，交通違規

（附註：此中文摘要由客座編輯楊育昇教授翻譯撰寫）

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穿戴 3D 列印技術製作豎腕副木之舒適度探討

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摘要

3D 列印是一種以數位模型檔案為基礎，能直接製造三維實體的技術。結合 3D 掃描技術它可以實現模具高度客製化的貼合度和舒適度。據此，本研究的目的為探討經由 3D 列印技術所製作的豎腕副木，與傳統手工成型的豎腕副木，使用者穿戴舒適度的差異。共計 10 位健康受測者參與本研究。固定型豎腕副木分別透過傳統手工成型與 3D 列印成型製程完成後，受測者以一星期為時間間隔，依隨機順序來分別穿戴這兩款副木連續八小時。完成穿戴八小時後，受測者接受問卷調查來詢問穿戴該款副木的舒適度。

結果顯示這兩種豎腕副木製程方法對穿戴舒適性並無顯著的差異。本研究結果顯示利用 3D 列印技術來協助治療師製作手腕副木是可行的方案；此方案優點包含重製方便、造型美觀與提升質感；但其最大缺點為製作大型副木是十分費時。3D 列印技術未來針對製作體積較小手指副木應會有更多深化的延伸應用，值得後續關注與研究。

關鍵字：3D 列印，3D 掃描，副木

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前言

副木 (splint) 為低溫熱塑型材質，可放在攝氏 60-70 度的熱水中軟化裁剪成型，是臨床上常用來做為一種固定、維持、控制和矯正姿態，或者是預防惡化、矯正關節變形、增進動作功能的輔助器材 (Duncan, 1989; Fess, 2002; Lannin & Ada, 2011) 。美國手部治療師學會依副木主要的功能，將副木種類歸納分類成三種型態 (Wong, 2002)，分別為（一）、固定型副木 (immobilization splint)：本體結構皆是固定無法移動，主要目的用來保護或支撐關節；（二）、動態型副木 (mobilization splint)： 部份結構是可移動，主要目的透過利用一些動力元件（如：彈性鋼絲、彈簧等）來協助患者增加關節被動動作、協助增進主動動作或替代喪失的動作;（三）、限制型副木 (restriction splint)：主要目的限定關節活動度於特定範圍角度內，讓肌肉或肌腱得以修復或者保護關節穩定性。

在臨床上，職能治療師會考慮個案的動作功能表現需求與相關潛在危險因子（如：是否有開放性傷口、壓瘡等），依根據個案肢體的形狀，進行副木的成型製作。然在成型製作過程中，副木需要貼附身體表面接觸的部位進行塑型，以達到穿戴時舒適服貼之效果；由於低溫熱塑材料加熱軟化塑型過程中，若溫度掌控不好且放置於體表上過久，易有產生燙傷之虞，因此往往就有賴於臨床職能治療師的過去經驗與手法，Tan 等人 (2021) 透過質性研究模型分析便指出，合身舒適副木製作確實有賴於治療師的經驗與製作模式 (working model)，這包括在適當時機便從體表取下副木，完成大致上的塑型，再進行適當修飾，以達到最佳客制化、服貼個體肢體表面外型的副木。製作不良的副木不僅穿戴時會感到不舒服，甚至會有壓迫之疼痛感，功能也可能受到不當的擺位角度而大幅度降低其效果 (Agnew & Maas, 1995; Callinan & Mathiowetz, 1996)；個案也往往會因「穿戴不適」或「認為沒有用」而導致棄用之效應。Stefanovich 等人 (2012) 提出影響副木配戴滿意度的因素包括：低溫熱塑性材料的選擇、熱塑成型的時機與處置手法、修剪邊緣處理方式、塑型過程的熟悉度、及副木成品的品質。

近幾年來 3D 列印技術應用於復健領域已得到廣泛討論，因為使用此類技術可以依個案體形，打造客製化的醫療輔具或矯正器，並大幅度提高個案使用的滿意度。3D 列印，又稱為積層製造，是指可任何列印三維物體的過程。根據美國材料試驗協會 (American Society for Testing Materials; ASTM) 的定義，「積層製造技術」是一種材料製程接合的過程，此技術利用電腦輔助設計軟體 (computer aided design, CAD) 處理三維模型資料，運用粉末狀或液態的原料，將材料層層堆疊產出立體物件 (ASTM, 2012)。利用 3D 列印技術來製作副木，主要得益於 3D 數位技術。通過 3D 掃描方法，藉由光照或接觸方式，將實際物體的立體資訊數位化轉換為電腦能直接處理的數據資料，為實際物件運算出立體圖檔，可以數位化保存、編輯或直接用於 3D 列印製作生產。因此，若使用 3D 掃描設備來掃描手部體表外貌，應可將患者的的手部體表外觀數位化，實現高度客製化的貼合度和舒適度。據此，本研究的目的為探討經由 3D 掃描搭配 3D 列印技術所製作的豎腕副木，與傳統手工成型的豎腕副木比較之下，使用者穿戴舒適度的差異。我們的研究假說為：應用 3D 列印技術所製作的豎腕副木，可以增加穿戴者的舒適感。

方法

一、受測者

本研究採用方便取樣，共計有 10 健康受測者（男性 5 位、女性 5 位）自願參與本實驗，平均年齡為 35.4 ± 7.8 歲。所有受測者需符合下面收案條件使納入為受測者： (1) 年紀介於 20 歲到 65 歲之間； (2) 本身上肢無任何神經、肌肉或骨骼系統的疾病（例如: 腕隧道症候群），足以影響到對上肢不舒適的感受。此外，受測者即使符合收案條件，但有下面排除條件亦排除參與實驗： (1) 本身接觸到塑膠材料之物品會產生過敏反應者； (2) 手腕或前臂皮膚有外傷或皮膚問題者。

二、研究流程

本研究採用重複測量設計 (repeated measures design)，受測者慣用手手腕將分別採用傳統手工成型與 3D 列印成型，這兩個不同的製程來製作臨床最常使用的固定型副木：豎腕副木 (Cock-up splint)。傳統手工製程方式皆由一位年資 10 年的治療師，採用測量繪型的製作方法進行手工製作，不使用預裁副木 (precut splint) 板來成型。首先依受測者手腕及前臂的體型，裁切所需要尺寸的低溫熱塑性副木（Easy-Cast Splints™，磊信國際有限公司，新北市）泡在 60～70 度的加熱箱數分鐘後，待其軟化成半透明狀時，拿起並移放到受測者手部進行塑型，此時受測者手部擺位於功能性位置 (functional position)，亦即手腕固定於在伸直 20 度的姿勢，並進行必要的修剪及邊緣平滑處置，當副木完全冷卻後，可用加熱槍及剪刀再加以最後的修飾平順，以達到穿戴服貼舒適之效果（如圖 1a 所示）。

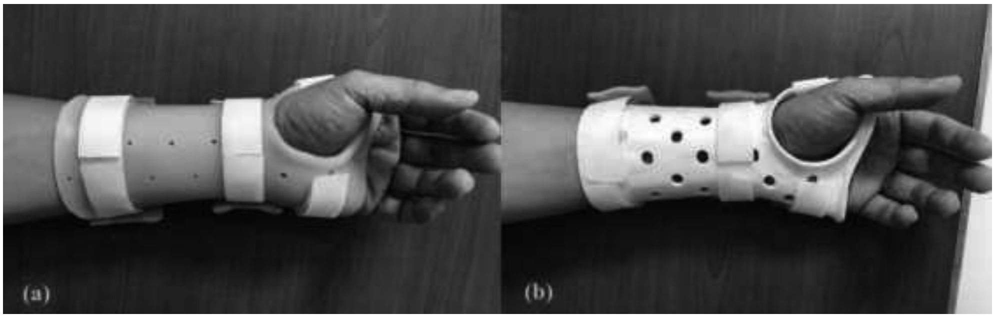

圖 1
不同製程之豎腕副木，左圖(a)為傳統手工製程、右圖(b)為 3D 列印製程。

3D 列印成型製程則皆由一位年資 8 年的治療師，使用 3D 掃描機 (SCANIFY 3D scanner, Fuel 3D Technologies, Chinnor, UK) 將受測者的手腕體表（如圖 2a 所示），逐一環繞掃描進行 3D 模型的重建，此時受測者手部擺位亦固定於功能性位置。3D 模型重建的方式是建立被掃描物體幾何表面的點雲 (point cloud)，藉由點雲建構出物體的表面形狀，點雲的密度越高，可建構出的模型精確度越高；之後透過 3D 電腦輔助設計軟體 (Autodesk Meshmixer, Autodesk Inc, San Rafael, CA) 進行後續手部 3D 模型的優化修飾後，再加以進行手部外殼成型步驟，以得出該手腕副木的 3D 模型檔案（如圖 2b 所示），接者將此檔案轉換成 3D 列印專用的立體

光刻 (stereolithography) 檔案格式，再由 3D 列印機開始列印製作出副木（如圖 1b 所示），其厚度與傳統手工製程的副木一致，皆為 3.2mm 厚。本研究所使用的 3D 列印機（D-Force V2 300，祥貿科技有限公司，台北市）是採用眾多 3D 列印技術其中之一的熱融沉積成型技術 (fused deposition modeling) ，這是目前最被廣泛使用且平價的成型技術。其列印材料已製成細絲捆卷的樣式，透過細絲供給器，將材料送至列印噴頭，其列印噴頭加熱至 210~220 度高溫後，將細絲熔化並擠出（擠出的材料寬度通常為 0.4 公厘）；其原理是將材料以熱熔的方式一層層的置放在設計的位置上再冷卻成型。本研究列印使用材質為丙烯腈丁二烯苯乙烯 (acrylonitrile butadiene styrene, ABS) 塑膠原料，是具有強度高、韌性好、易於加工成型的熱塑型高分子材料，且價格便宜，是 3D 列印機中最常用選擇的材料。

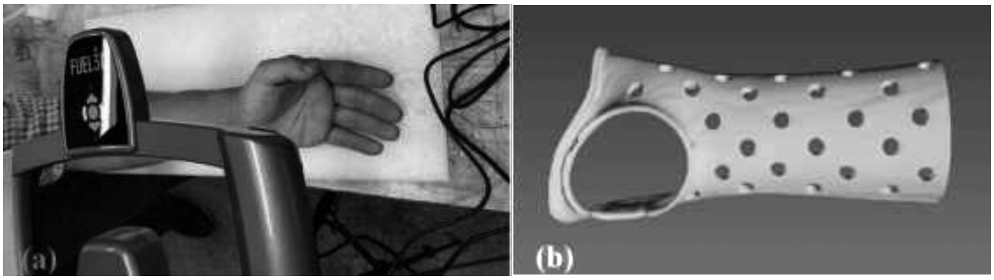

圖 2
3D 列印建模過程，左圖(a)為 3D 掃描步驟、右圖(b)為後製 3D 模型檔案。

待這兩款豎腕副木製作完成後，受測者被要求分別穿戴每一款豎腕副木連續 8 個小時，並於每一款副木結束穿戴後填寫一份舒適度問卷調查，來瞭解該款副木對於手部的舒適性影響；這兩款副木穿戴的前後順序會由研究者依電腦程式隨機抽樣決定之，且兩款副木穿戴時間間隔為一週以避免短期記憶效應。在舒適度問卷調查上採用視覺類比量表 (Visual Analog Scale, VAS)，在一條 10 公分長度的水平直線，以最左處作為零點 (0cm)，代表最不滿意，而直線的最右端 (10cm) 為最滿意。請受測者就下面穿戴豎腕副木可能出現壓點的部位進行逐一的評量：前臂、手腕橈側與尺側莖突、虎口、手掌處、與大拇指基底處（掌指關節）部位。受測者就每一部位分別在直線上以筆垂畫出舒適的感覺在幾公分處，之後研究者將所測量的公分值記錄下來，數值越高，表示該部位的滿意程度越高。最後也請受測

者就整體穿戴舒適度給予評價。整份問卷共計有七題，並提供一題開放性問題，讓受測者提供質性的回饋意見。

三、統計分析

使用描述性統計以平均值分析，了解受測者對於兩款不同製程的副木，穿戴後手部舒適度之滿意程度認知。此外，為比較受測者對於傳統手工與 3D 列印兩款不同製程所製作出來的副木，在整體穿戴舒適度差異性，以無母數統計中之魏克生符號檢定 (Wilcoxon signed-rank test) 方法，來檢定兩款的差異，顯著水準 α 設為 0.05。所有資料皆使用 IBM SPSS Statistics for Windows 套裝軟體 (IBM Corp., Armonk, NY) 進行相關統計分析。

結果

圖 3 為穿戴兩款不同製程副木後，在手腕區域部位舒適度問卷調查結果，兩款在這六個手腕區域部位的舒適度並無明顯的差異性。穿戴傳統手工與 3D 列印製程副木後，以平均分數（± 標準差）在手腕橈側舒適度而言，分別為 6.29 ± 0.99 與 6.90 ± 1.48；在手腕尺側舒適度而言，分別為 6.80 ± 0.85 與 7.32 ± 1.29；在虎口舒適度而言，分別為 6.35 ± 1.19 與 7.35 ± 1.23；在手掌處舒適度而言，分別為 6.84 ± 1.02 與 7.28 ± 1.3；在前臂處舒適度而言，分別為 6.83 ± 0.77 與 6.86 ± 1.56；在大拇指處舒適度而言，分別為 6.72 ± 0.94 與 7.57 ± 1.38；而就整體而言，受測者對穿戴兩款副木的舒適度皆達到約七分的舒適感受，分別為 6.71 ± 0.89 與 7.07 ± 1.35，兩者之間的評價並無達到統計上顯著的差異 (p =.26) 。在開放意見上，兩位參與者指出在 3D 列印製程過程中，「不會花很久時間完成」，「不用觸摸到我的手就可完成工作」，「但要等一陣子才能拿到手架，不像手工製作當場可拿到手架」；有三位參與者皆反應 3D 列印製程的副木，「孔洞比較大，感覺比較能通氣」，「可以選擇顏色很棒」。

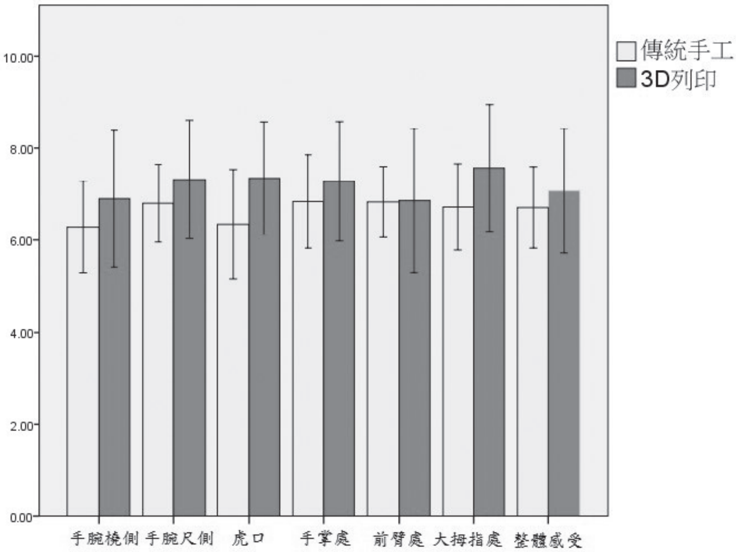

圖 3
穿戴兩款豎腕副木後，手腕區域部位舒適度問卷調查結果

討論

本研究的結果顯示搭配 3D 掃描以 3D 列印技術所製作出來的的固定型豎腕副木，相較於一般傳統手工製程所製作出來的副木，在整體穿戴舒適上並無顯著的差異。此外就該款豎腕副木在製作上最常出現壓點（如：手腕橈骨/尺骨莖突處、手掌虎口處等），易產生不舒適的部位，逐一進行調查，發現 3D 列印製程的副木，在這些區域穿戴的感受，與傳統手工製程的副木亦無明顯的差異。據此 3D 列印技術來製作現有固定型副木是可行的選項。相較於傳統手工製程需在患者手部體表直接成型加工製作的方式，3D 列印的特色是省去了需要透過實體模具加工的手續，可直接從 CAD 軟體的三維模型數據得到實體零件，並在電腦軟體上進行必要的修飾加工，大幅度的降低患者所需要現身暴露於製程的時間。在先前有關使用 3D 列印來協助治療師製作透明塑膠面罩的研究結果亦指出，3D 列印製程方案對患者而言是省時且較舒適（梁文隆，2018）。另為降低 COVID-19 感染風險而需要避免不

必要的接觸，3D 列印製程方案採用非接觸式的 3D 掃瞄方式取得手部模型數據，可成功達到防疫的要求。況且這些模型數據日後皆可用保留於電腦資料庫內，若患者因損壞或遺失等原因，需要重新製作全新副木，卻礙於其它可能因素（如：身處偏遠地區、或居家隔離/檢疫中），無法親自現身到場製作，臨床治療師則可採用 3D 列印製程方案，調出電腦資料庫內模型數據，在現場無患者情境下，直接進行重製的工作，這是傳統手工製程無法做到的一點。

客制化的美觀外型設計亦是 3D 列印的另一特色，透過 3D 電腦輔助設計軟體，可以依使用者喜愛或設計者需求進行各種外型的設計。以本研究的設計為例，在長時間的副木使用上，透氣度是影響穿戴舒適的主要因素之一；透氣性不好的話，患者穿戴時就會感到悶熱與潮濕，自然也就很難長期穿戴使用。儘管現有市售低溫熱塑副木材料皆有預先洞孔設計，增加材料透氣性，但因孔徑仍太小，透氣度仍嫌不足，在臨床上經常接受到患者的抱怨。因而本研究在 3D 模型設計上，在仍保持結構的支撐強度下，特意將前臂區域加大透氣孔徑，以期能改善原有透氣度不佳的問題。除此之外，因 3D 列印製程採用線料加熱後擠出堆積之原理，所以可以在製程過程中選用不同顏色與物料特性（如：木質線材、金屬類線材、碳纖維線材、熱塑性彈性線材等）的線材，達到多色美觀及不同強度與質感的效果 (Ganesan, Adel, & Luximon, 2016) ，這都可以大幅度提高原有副木的美觀與質感。

然而 3D 列印製程雖具有上述的優點，但實際完成製作副木時間上，確實比傳統手工製程更費時完成。雖然在 3D 掃描取模上只需花費數分鐘即可完成，但後續軟體建模、平滑修飾與轉檔上的操作時間，卻需要依原始取模檔案的完整性來決定所需花費時間而定，平均從數十分鐘到一小時不等，而從 3D 列印機列印出副木成品則需約費時 4 小時左右，所以整體從掃描取模到豎腕副木成品製作完成，共約需 6 小時得以完成；相較於傳統手工製程，從手工量測、加熱軟化材量、服貼成型，豎腕副木大致可在半小時完成。這製作時間上的差異，大幅度限制了 3D 列印製程方案在臨床上的應用性。由於 3D 列印製程方案是採用熱融沉積成型技術，以每層 0.02~0.4 mm 厚度（依機種列印解析度設定）逐一疊積成型，故必然需要費大量時間完成大型樣式的副木製作。然而若針對製作體積較小的副木（如：鵝頸指矯正副木，或鈕扣指矯正副木等），則具有十分潛在的應用價值，最近已有不少研

究開始關注此課題 (Arulmozhi et al., 2018; Nam et al., 2018; Portnoy et al., 2020; Zolfagharian et al., 2020)，因為這類體積小的副木製作時間較短，依研究者的經驗，約半小時即可完成，且所需材料成本低廉，可事先預列印好不同尺寸的手指副木，讓患者試戴最合適他／她手指體形的副木，這些事先準備工作是可提昇 3D 列印製程方案在臨床的實用性。

臨床治療師多數對 CAD 製圖軟體不熟悉，也是另一個限制應用 3D 列印製程方案的主因。要讓一個 3D 物件被列印成型，最重要的第一步就是要學會製作 3D 建模，透過軟體的編輯及修正，便可設計出使用者想要的 3D 模型並快速輸出成 3D 實體物件。然而這畢竟不是每個人都具備相關能力，尤其是在職能治療師養成教育課程上更是缺乏。因此建議未來在養成教育課綱內及繼續教育課程中，可納入新興科技的相關軟體技能課題，讓臨床治療師及學生對於操作相關資訊軟體不會感到生疏而排斥學習。Benham 與 San 學者 (2020) 指出經過 12 週 3D 列印入門課程可增加職能治療學生對新興科技的接受度； Wagner 等學者 (2018) 已成功將此 3D 列印科技的知識導入到職能治療教育課程內，而就研究者所知，部份國內職能治療學系亦有開設相關選修課程，期望有更多的學校投入這新興科技教育，讓職能治療逐漸朝向科技化介入處置之發展。

本篇應用 3D 印列於手腕副木製作上仍處於早期研究階段，尚有許多研究限制。首先本研究結果僅反應出穿戴舒適度，整體研究的廣度與深度仍有不足之處。未來相關研究可就現有的 3D 副木模型使用有限元素法 (finite element method) 進行結構力學模擬分析，進而開發出創新造型、輕量化且具高強度結構設計的副木。其次，製作的時間並未被確實紀錄，實難佐證兩者製程之間製作時間的差異性；然而傳統手工低溫熱塑性副木具有加工方便，可依患者的狀態變化（例如：水腫），或者擺位角度不夠理想，隨時進行二次加工調整之優點，這是 3D 列印成品無法進行彈性修正的缺點。因本研究過程中著重於學習 3D 掃描、3D 建模與使用 3D 列印機製作出副木成品，故忽略了選用更佳的問卷工具：「台灣版魁北克輔具使用者滿意度評量」（陳莞音，2007），該問卷可提供進深一步的資訊，如：尺寸、重量、耐用度、與使用效果的反應，更全方面來評量使用者對手部副木配戴之滿意度，這可做為未來相關探討輔具研究之參考。

結論

採用 3D 列印來製作手部副木具有重製方便、造型美觀與提升質感的優點，在臨床應用有不容小覷的潛力。本研究研究結果已初步驗驗 3D 列印製程所製作出來的手腕固定型豎腕副木，與傳統手工製作的同款樣式的副木在穿戴舒適上並無顯著的差異。相較手工製作副木穿戴的舒適性有賴於治療師的經驗與手法，3D 列印製程可藉由數位化的 3D 建模檔案進行製作或重製的步驟，不易受到人工經驗值的干擾而影響到最終副木成品的穿戴舒適性。就現有 3D 列印技術，大型副木的製作上仍十分費時，然而未來針對製作體積較小手指副木應會很廣泛的應用潛力。

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Original article

Evaluation of Wearing Comfort of the Cock-up Splint by 3D Printing Technology

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Abstract

3D printing is a type of manufacturing process that uses a digital model to create a 3D object. The combined use of 3D scanning and 3D printing technologies creates a comfortable and custom fit mold. Therefore, the aim of this study was to investigate the differences of wearing comfort between cock-up splints fabricated with 3D printing technology and with conventional manual work. Ten able-bodied participants participated in this study. After fabrication of wrist cock-up splints by conventional manual fabrication and 3D printing was done, participants were assigned to wear these two types of wrist cock-up splints. The sequence of the wearing splint was randomly assigned with a one-week interval. After eight-hour wearing, participants were asked to indicate the comfort level. The results indicated that no differences of wear-comfort were noticed between these two molds. 3D printing technology appears to be a promising method to help therapists fabricate the wrist splint. The advantages of 3D printing include easy replication, aesthetic features, and good quality. However, the use of 3D printing to fabricate large splints is relatively time-consuming. Therefore, the application of 3D printing for fabrication of small finger splints deserves further attention and in-depth study.

Keywords: *3D Printing, 3D Scanning, Splints*

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原著

虛擬實境與簡訊提醒於思覺失調症個案之應用與成效:前驅試驗

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摘要

促進思覺失調症個案體能活動參與是一項重要挑戰，新興科技(如：虛擬實境，virtual reality, VR)、溝通與訊息科技可能提供常規介入之輔助。本研究旨在探討虛擬實境健走活動對思覺失調症個案之可行性、對時間使用之效益，以及簡訊提醒(short message reminders, SMR) 之成效。本研究採隨機對照試驗，受試者隨機分派到虛擬實境健走與簡訊提醒組 (VR+SMR) 、虛擬實境健走組 (VR-Only) 與控制組。VR+SMR 組、VR-Only 組接受每週 5 次，每次 50 分鐘之虛擬實境健走達 4 週，控制組則參與同樣時間於病房內自主行走。VR+SMR 組在介入後會收到額外簡訊提醒。總共 18 位受試者參與本研究。整體虛擬實境健走出席率為 96.25%，並有 90.90%的訓練達成目標心率。結果顯示週末運動時間改變量上，三組於後測 (p=.016) 與追蹤階段 (p=.013) 達顯著差異，事後比較顯示後測時 VR+SMS 組改變量顯著較控制組高 (p=.008) ，VR-Only 組於亦有邊緣顯著性 (p=.020) ；於追蹤時，僅有 VR+SMR 組週末運動時間改變量顯著較控制組高 (p=.008) 。在平日運動時間使用與其他次要結果評量則無顯著差異。本研究初步支持虛擬實境健走之可行性，且可促進思覺失調症個案於週末之運動參與，而簡訊提醒可維持此行為改變。

關鍵字：虛擬實境，簡訊提醒，健康促進，時間使用，思覺失調症

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前言

思覺失調症個案主要臨床症狀為正性症狀、負性症狀及認知功能之缺損 (Stępnicki et al., 2018)，他們的自我概念及日常生活常規事項，會因負性症狀、缺乏適當環境刺激以及功能之缺損而造成其活動參與之障礙 (Bejerholm & Eklund, 2007)，其亦有較高代謝症候群與心血管疾病之風險，造成生活品質低下並增加死亡率 (Allison et al., 2009; Brown et al., 2010)。部分研究也發現嚴重心智疾患個案的生活，常傾向孤立且多靜態活動，較多時間用於睡眠及休息 (Bejerholm & Eklund, 2007; Minato & Zemke, 2004)；與常人相比，思覺失調類群疾患個案較少時間用於功能性、社交或休閒活動，他們耗費較多時間休息或是「無所事事」(doing nothing)，而負性症狀與被動參與活動有關聯 (Cella et al., 2016)。研究也顯示時間使用、職能參與和思覺失調類群疾患的健康狀態、認知功能有顯著關聯性 (Bejerholm & Eklund, 2006, 2007; Lexén & Bejerholm, 2018)，國外過去關於嚴重心智疾患者及一般人之時間使用的調查報告，顯示失能會對於時間分配、活動參與頻率及受雇情形等造成影響，干擾其時間使用情形進而影響生活品質 (Eklund et al., 2009)。

體能活動參與是思覺失調症個案復元歷程中的重要元素，職能治療哲理認為人們即使在困難的情況下，仍必須在工作、休息、休閒與睡眠之間取得平衡，亦即，思覺失調症個案與一般大眾具有同樣的休閒活動及體能活動量之需求 (Meyer, 1977)。近年的後設分析則支持運動介入可改善個案的精神症狀、認知功能、憂鬱、生活品質及整體功能 (Dauwan et al., 2016; Firth et al., 2015; Firth et al., 2017) 等，亦有證據支持體能活動介入與對照組相比，對於思覺失調類群個案的攝氧量亦有中等程度之效益 (Vancampfort et al., 2015)。因此，體能活動之介入已是精障者常規介入服務之一 (Gorczynski & Faulkner, 2010)。

然而，思覺失調症之負性症狀、自我效能低落、抗精神病藥物之副作用、較差的身體狀況，不健康之生活習慣以及社交疏離等狀況，與其未能達到足夠的體能活動量、生活上亦未有規律運動習慣具有關聯性 (Vancampfort et al., 2012)；Stubbs 等人 (2016) 的後設分析顯示思覺失調症個案較少參與中等或高強度的身體活動，且僅 56.6%的個案有達到每週 150 分鐘的中等強度體能活動參與。Chen 等人

(2017b) 針對台灣的精神障礙者進行之質性訪談，亦發現健康狀況不佳、自我效能低落、缺乏家人與朋友支持、害怕他人眼光及環境不便利等，為持續參與體能活動之干擾因子；另一方面，促進因子則有:參與身體活動以增進健康的動機、參與喜好的身體活動、家人與朋友的支持、專業人員的參與以及便利的運動器材或設施等 (Chen et al., 2017b)。因此，如何增進思覺失調症參與體能活動之動機，以及持續地進行體能活動，乃是精神復健從業人員亟需思考及克服之一項問題。

虛擬實境 (virtual reality) 是以電腦為輔助的現代化技術，可使用圖片、聲音及其他感覺輸入來創造一可即時互動的電腦化虛擬情境 (Kim et al., 2009)，此技術可提供大量類似真實情境之練習機會，與即時感覺回饋，並可個別化調整困難度 (Tsang & Man, 2013)。虛擬實境之介面，可分為沉浸式 (immersive virtual reality environment) 與非沉浸式 (non-immersive virtual reality environment)。兩種方式在技術上有所不同，沉浸式虛擬實境使用頭戴顯示裝置 (head-mounted display)，參與者透過此裝置進行三度空間的虛擬實境沉浸體驗與互動；而非沉浸式虛擬實境又被稱為互動式介面 (interactive virtual reality)，受試者會站在傳統的投影或電視螢幕前，透過遊戲搖桿或控制器，讓受試者與虛擬環境進行互動，此種技術則較缺乏沉浸式體驗 (Bisso et al., 2020)。

虛擬實境也被用來評量思覺失調症之認知 (Ku et al., 2003)、情緒 (Ku et al., 2005)、行為特徵 (Ku et al., 2006)以及藥物處理技巧 (Kurtz et al., 2007)；於介入上，Freeman 於 2008 年提出使用沉浸式虛擬實境合併認知行為治療的原則用以治療精神症狀 (Freeman, 2008)，此後相關應用逐漸被探討，近年的系統性回顧整理 6 篇臨床試驗證據，初步支持沉浸式虛擬實境為治療思覺失調類群疾患之妄想、幻覺、認知與社交技巧安全而有效的方式 (Bisso et al., 2020)。Chan 等人 (2010) 使用商業化的虛擬實境軟體，搭配 2D 影像投影，讓思覺失調類群個案進行接球、足球守門員等活動，結果支持此類練習可改善老年思覺失調症的記憶力，然而此研究有選擇性偏差及耗損性偏差之風險，因此非沉浸式虛擬實境之應用仍待研究探討。

信息及通訊科技 (Information and communication technology) 包含使用手機、電腦、電視等任何影音技術，用以進行訊息之溝通，是傳遞與增進個案對心智健康之覺察的有效方式 (Välimäki et al., 2012)，使用手機等通訊軟體，被認為是一項相

當有用的方式來促進普羅大眾的體能活動參與 (Pratt et al., 2012)；手機簡訊 (Short-message) 是高度可及的通訊科技，美國於 2011 年對嚴重心智疾患的調查顯示 72%的個案擁有手機，32%的手機使用者認可手機簡訊為服務提供管道 (Ben-Zeev et al., 2014)。Naslund 等人 (2016) 分析參加某生活型態介入研究的嚴重心智疾患受試者，發現 93%擁有手機，78%有使用簡訊的習慣，50%的受試者擁有智慧型手機。Firth 等人 (2016) 的後設分析整合 12 篇提及精障者手機使用狀況的研究報告，擁有手機的比率平均為 66.4%，並在 2007 年以後擁有手機的比率顯著提升，在 2013 年以後的研究報告整體使用率則為 81.4%，作者的結論提及，因應精障者手機使用的廣泛發展，必須投入手機應用於精障者的應用研究發展。

Griffith (2020)的系統性回顧則整理了使用簡訊來支持對嚴重精神疾患者之身體活動介入的研究，發現簡訊之使用可分成三種類型: (1) 作為提醒，鼓勵參與身體活動、(2) 直接作為介入方式、(3) 作為社交支持之媒介；其中仍以將簡訊作為提醒為最常使用之方式。在一項探討單向簡訊與雙向簡訊對促進嚴重精神疾患者體能活動參與的單盲隨機控制試驗中 (Chen et al., 2017a)，研究者設計了鼓勵運動的簡訊，並隨著介入時間逐漸減少每週傳送的簡訊數量，總計 12 週的介入共傳送 32 封簡訊給受試者，雙向簡訊組的受試者需要回傳一半以上的提醒簡訊，結果發現雙向簡訊可於第 6、12 週增進受試者每日步行數，並有 73%受試者認為簡訊可鼓勵他們起始運動。在其他精障者生活型態介入研究中，曾以穿戴式設備，搭配每週簡訊提醒受試者運動，鼓勵受試者達到每週 150 分鐘體能活動量，介入後發現每日步行數越多與減重越多具有相關，作者認為生活型態安排讓精障者每天走得越多，可能促進其減重 (Naslund et al., 2016)，而受試者認同簡訊提醒具有鼓勵運動之作用 (Aschbrenner et al., 2016)。

綜覽文獻，近年有越來越多研究揭示新興科技對思覺失調症個案之應用之迫切性，過往研究尚未探討非沉浸式虛擬實境技術對於促進精障者體能活動參與之效益，而關於簡訊提醒的成效也尚待更多研究實證累積。因此，本研究之主要目的有二： (1) 檢驗虛擬實境行走活動對慢性思覺失調症個案之可行性，以及對體能活動參與時間之成效；(2) 探討簡訊提醒對其持續參與體能活動之效果。

研究方法

一、研究設計

本研究為隨機對照試驗，於南部某醫學中心日間留院以便利取樣徵召受試者。以收案及排除條件篩選受試者後，取得受試者同意書，將每位受試者編碼並放入密封、不透明之信封中，使用 Excel 電腦亂數表進行隨機分派，受試者以 1:1:1 之比例隨機分配到虛擬實境健走及簡訊提醒組 (VR+SMR)、虛擬實境健走組 (VR-Only) 或控制組。當進行前測評量完成後再打開信封依隨機分派結果進行研究介入。所有受試者會接受前測 (T0)、後測 (T1) 與追蹤 (T2) 等三次評估，前測評估為研究介入前，後測於 4 週的虛擬實境健走介入結束時進行，追蹤則於 4 週的簡訊提醒階段結束後進行（圖 1）。

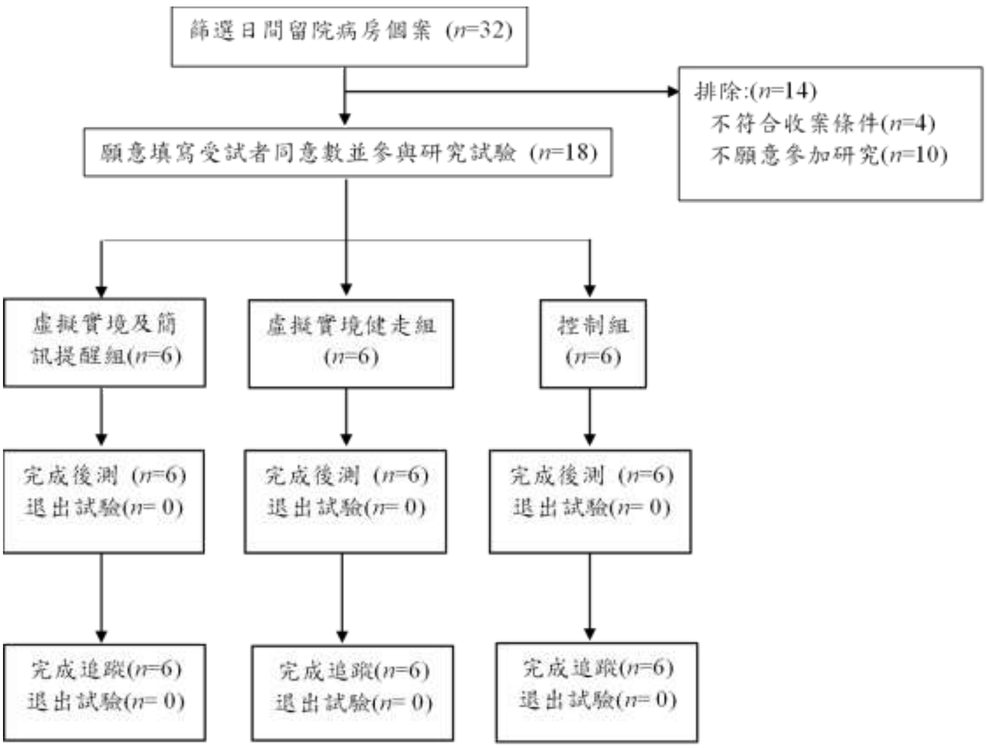

圖 1
收案流程圖

本研究受試者的收錄條件如下: (1) 符合 DSM-5 診斷準則之思覺失調症或思覺失調類群個案；(2) 年齡介於 20-65 歲之成年人；(3) 其疾病狀態穩定，一個月以上未調整主要抗精神病藥物；(4) 能以國台語溝通，並配合簡單指令者；(5) 可自主行走，經評估後無高風險跌倒之虞者；(6) 願意參與本研究，並填寫受試者同意書者。若受試者有下列情形，則予以排除: (1) 無法負荷中度運動強度者；(2) 有癲癇、嚴重心血管病史者；(3) 肢體靈活度受限或平衡感差者，如中風、神經肌肉疾患；(4) 無法理解與配合研究內容者。本研究計畫經長庚醫療財團法人人體試驗倫理委員會審查通過。有意願參與之個案經篩選後，研究者將告知其研究流程及目的，並給予受試者同意書，完成簽署後始納入收案。

二、實驗介入

本研究中，虛擬實境健走組與虛擬實境及簡訊提醒組之受試者，皆接受虛擬實境健走活動；而虛擬實境及簡訊提醒組的受試者，在虛擬實境健走活動結束後，每週另有簡訊提醒參與身體活動。以下就虛擬實境健走與簡訊提醒分別介紹。

（一）虛擬實境健走

本研究採用非沉浸式的虛擬實境技術，以有藍芽連線功能的跑步機（BH, G6421B RTAERO PRO，必艾奇亞洲有限公司），搭配免費 App 軟體─Run on Earth (PAFERS Tech Co.) 來進行；Run on Earth 可結合 Google Map 之街景模式，當跑步機使用藍芽傳輸與平板電腦 (Acer, ICONIA ONE 8 B1820) 連結後（圖 2），可如一般 Google Map 街景模式設定行走路線，當受試者於跑步機上行走時，該 App 會依照 Google Map 中的距離、路線坡度，配合受試者的行走速度變換街景與跑步機之坡度。

圖 2

跑步機虛擬實境健走環境佈置圖

a. 影音輸出設備採用液晶電視螢幕，以 HDMI 線與平板電腦進行連線

b. 跑步機採用含藍芽連線功能的跑步機，方可與 app 共同運作

c. 平板電腦運作 app 程式，以藍芽和跑步機連線運作，以 HDMI 線與影音輸出設備連線

研究者在每次開始運動前，先與受試者討論住家附近之理想健走路線，並設定好路線，當受試者開始於跑步機行走時，搭配影音設備 (Heran, HD-32VGN2A) 將街景圖示放大呈現於螢幕中（圖 2），使受試者能依照其行走速度同時感受街景與坡度之變化。虛擬實境健走活動採專業人員與受試者為 1 對 2 方式進行，每週 5 次，每次 50 分鐘：含 10 分鐘之慢走暖身、30 分鐘快走與 10 分鐘之收操，共持續 4 週。運動期間以跑 Polar FT2 (Polar Electro Oy.) 心率表，每 5 分鐘監測運動強

度，根據 Bredlin 等人 (2013) 先前之方案，該研究以中度運動強度為主，採用 12 週研究設計，每週 3 次、每次 30 分鐘的介入，每位受試者總計 1080 分鐘的有氧運動介入；本研究考量研究團隊之可用資源，而設計 4 週介入，每週 5 次，每次 50 分鐘，總計 1000 分鐘；介入第 1 週設定運動強度目標為 50-63%最大心率，第 2-3 週設定運動強度目標為 64-70%最大心率，第 4 週設定運動強度目標為 70-77%最大心率 (Bredin et al., 2013) 。最大心率值為 220 減去年齡 (American College of Sports Medicine, 2103)。

若受試者在 40 分鐘以內便走完該日原訂路線，便請受試者原路再走一次，直至走滿 40 分鐘為止。所有受試者皆維持常規治療介入，包含藥物治療、護理介入、職前訓練、娛樂治療等，當虛擬實境練習進行時，控制組則於病房內自主行走，每天 5 次、每次 50 分鐘，受試者可以自主決定行走速度，研究團隊給予兩組受試者相等之口頭鼓勵，例如：加油、努力走完等，而控制組自主行走時無專業人員監督運動量。

（二）簡訊提醒

分配到虛擬實境與簡訊組的受試者會額外收到簡訊，提醒其繼續進行散步或其他體能活動，並鼓勵受試者以簡訊回傳運動情形與研究團隊進行互動，參考先前的研究 (Chen et al., 2017a)，受試者第一週會收到 5 則手機簡訊提醒，之後逐週遞減 1 則，共持續 4 週，總計 14 封簡訊；簡訊為研究團隊手動寄發，第一週的 5 則簡訊於週一、週三、週五、週六及週日寄發，之後的遞減為依次減少週三、週五、週日的簡訊提醒，平日的寄發時間為晚間 18:00–20:00 之間，週末的寄發時間為中午 12:00-13:00 之間；簡訊的內容例如：「回家之後的傍晚或夜間，氣候宜人，要不要出門運動一下呢？」、「嗨！今天天氣很好，要不要出門走走呢？」、「今天雖然下雨，不過也可以等雨停之後，在家裡附近走走吧？」。若受試者本身並無手機者，於研究期間將提供其手機並教導其使用方法至熟稔。

三、結果評量

（一）可行性評量

本研究記錄受試者出席虛擬實境健走之出席率，以及運動強度達成率，即每次運動是否達成目標心率之百分比做為可行性之指標。此外，亦記錄: (1) 自覺費力指數 (Rating of Perceived Exertion, RPE)，採 10 分量尺，0 分為沒有；0.5 分為極弱；1 分為很弱；2 分為弱；3 分為中等；4 分為有點強；5 分為強；6-9 分為很強；10 分為極強 (Noble et al., 1983) 。 (2) Polar 心率表之平均心率、最大心率做為虛擬實境健走運動強度之參考。此外，研究團隊也記錄各種運動過程中的不良事件，例如痠痛、跌倒、肌肉骨骼傷害等。

（二）時間使用評量

本研究採用職能活動問卷 (Occupational questionnaire) 來評量時間使用。職能活動問卷是一項可以用來調查個人每天時間使用的工具，每日的時間以 30 分鐘為單位分段，受試者填答每個時段的活動內容，並將之歸類為工作、日常活動、休閒娛樂或休息等，並且對於活動的表現、重要性與喜好進行評估；職能活動問卷是一項可用以追蹤時間使用的良好工具，並可有效預測運動行為 (Rust et al., 1987)，本測驗之再測信度與同時效度已被驗證 (Smith et al., 1986)。於研究進行期間，請受試者每週填寫 2 次，其中一次為週一以獲得受試者於週末之時間使用情形，另一次為週二到週五之間，以獲得受試者於平日之時間使用。

因本研究旨探討運動參與狀況，故另外由第一、第二作者針對受試者填答內容，分別獨立計算體能活動或運動參與時間，當有不一致時，則經討論取得共識（評分者間一致性為 Kappa=.904, p=.000）。本研究以平日及週末的運動參與時間為主要結果評量，其他如工作、休閒娛樂、日常活動、休息等的時間使用為次要評量。

四、統計分析

以次數分布、百分比來進行人口統計學之類別變項、出席率與運動強度達成率的描述性統計；連續變項則以平均值、標準差呈現。前測在三組之差異，因小樣本故採 Kruskal-Wallis Test、卡方檢定來檢定。主要結果評量與次要結果評量，採每週填寫之職能活動問卷的平均值來進行計算，本研究將原始分數以平均值、標準差呈現，推論統計採改變分數進行考驗，改變分數包含: (1) 前測與後測之差異 (T1-T0)、(2) 前測與追蹤之差異 (T2-T0)、(3) 後測與追蹤之差異 (T2-T1)，並使用 Kruskal-Wallis Test 進行組間比較，設定 α=.05，若出現顯著差異，進一步使用 Mann-Whitney U test with Bonferroni correction 來進行事後比較。本研究共有三組別，故事後檢定共有 3 個比較，採用 Bonferroni correction 後，形成 α=.05/3 之校正 *p* 值，故以 *p*=.017 作為臨界值來判斷事後比較顯著性。研究資料以 SPSS 22.0 版 (SPSS Inc, Chicago, Illinois) 統計軟體進行。

結果

一、人口學變項

本研究徵召 18 位受試者參與研究（6 位 VR+SMR 組、6 位 VR-Only 組、6 位控制組），無受試者退出。三組別在平均年齡無顯著差異 (*p*=.472)，受試者以慢性思覺失調症為主，三組別罹病年數無顯著差異 (*p*=.534)。性別、身體質量指數、教育程度、居住狀況與婚姻狀況上無顯著差異 (*p*s>.05) （表 1）；此外，三組之受試者擁有手機的比率亦無顯著差異，介入前運動習慣與工作訓練狀態亦無統計顯著差異 (*p*s>.05) （表 1）。

二、可行性

在虛擬實境健走活動方面，VR+SMR 組的出席率為 99.16%，VR-Only 組為 93.33%，整體出席率為 96.25%（表 2）。而在運動強度達成率上，VR+SMR 組為 92.43%，VR-Only 組為 89.29%，整體運動達成率為 90.90%。兩組別受試者在虛擬

實境健走活動中，平均心率為 129.37 次/分鐘，最大心率平均值為 141.24 次/分鐘，平均自覺費力指數為 5.99 分；虛擬實境健走活動有 6 人次主訴腳酸，3 人次主訴疲累，3 人次主訴頭暈，在適度休息皆可緩解，無骨骼肌肉傷害或其他不良事件（表 2）。

表 1

人口統計學基本資料

	VR+SMR (*n*=6)	VR-Only (*n*=6)	控制組 (*n*=6)	*p* value
年齡[a]	32.33 (13.09)	37.33 (10.56)	41.33 (9.42)	.472
性別（男性/女性）[b]	4 (66.67)/2 (33.33)	3 (50.00) / 3 (50.00)	2 (33.33) / 4 (66.67)	.513
身體質量指數[a]	28.81 (5.11)	24.36 (2.76)	26.08 (8.86)	.459
發病年數[a]	13.17 (8.86)	15.50 (6.69)	16.17 (6.68)	.534
教育程度[b]				
國中	0 (0)	1 (16.67)	3 (50.00)	
高中職	4 (66.67)	3 (50.00)	2 (33.33)	.703
大學/大專	2 (33.33)	2 (33.33)	1 (16.67)	
居住狀況[b]				
獨居	0 (0)	1 (16.67)	0 (0)	.347
非獨居	6 (100.00)	5 (83.33)	6 (100.00)	
婚姻狀況[b]				
單身	5 (83.33)	5 (83.33)	4 (66.66)	
結婚	1 (16.67)	1 (16.67)	1 (16.67)	.710
離婚	0 (0)	0 (0)	1 (16.67)	
有個人手機[b]				
是	5 (83.33)	5 (83.33)	3 (50.00)	.330
否	1 (16.67)	1 (16.67)	3 (50.00)	
每週運動習慣[a]				
3 次以上	4 (66.67)	3 (50.00)	3 (50.00)	.407
3 次以下	2 (33.33)	3 (50.00)	3 (50.00)	
正接受工作訓練[b]				
是	5 (83.33)	4 (66.67)	5 (83.33)	.725
否	1 (16.67)	2 (33.33)	1 (16.67)	

[a] 採 Kruskal-Wallis Test，數值為平均數，括號內為標準差

[b] 採卡方檢定，數值為次數，括號內為百分比

表 2
可行性評估

	全部接受虛擬實境者 (VR+SMR & VR-Only) (*n*=12)	VR+SMR (*n*=6)	VR-Only (*n*=6)
出席率，%（人次）	96.25 % (231/240)	99.16 % (119/120)	93.33 % (112/120)
運動強度達成率，%（人次）	90.90 % (210/231)	92.43 % (110/119)	89.29 % (100/112)
平均心率，bpm	129.37	131.12	127.53
最大心率平均，bpm	141.24	143.77	138.50
自覺費力指數（1-10 分）	5.99	5.93	6.04
不良事件，人次 (%)			
腳酸	6 (2.60%)	5 (4.20%)	1 (0.89%)
疲累	3 (1.30%)	1 (0.84%)	2 (1.79%)
頭暈	3 (1.30%)	3 (2.52%)	0 (0%)
骨骼肌肉傷害	0 (0%)	0 (0%)	0 (0%)

皮爾森相關顯示，ASD 青少年各面向生活品質分別與年齡、嚴重程度皆無顯著相關 (*ps* >0.05) 。低登錄量分數越高與各面向生活品質呈中度負相關 (*r*=-0.33~-0.51, *p*<0.01) ，代表低登錄量相關的行為表現越多，其生活品質越差。感覺尋求則與各面向生活品質未達顯著相關 (*ps*>0.05) 。感覺敏感與各面向生活品質呈低至中度負相關 (*r*=-0.30~-0.45, *p*<0.01) ，即感覺敏感相關的行為表現越多，其生活品質越差。最後，感覺逃避與身體、社會及學校功能未達顯著相關 (*ps*>0.05) ，與情緒功能達中度負相關 (*r*=-0.34, *p*<0.01) ，與社會心理及整體生活品質達低度負相關 (*r*=-0.28~-0.29, *p*<0.01) ，即感覺逃避相關的表現行為越多，在情緒、社會心理與整體生活品質越差（見表 2）。

三、時間使用成效

首先，三組於前測在主要及次要評量，未達統計顯著差異。於主要結果評量，平日的運動時間改變量上，三組別於前測、後測與追蹤之間的變化量未達統計顯著差異 (*ps*>.05) （表 3、圖 3）。在週末運動時間改變量上，在前測與後測之間 (T1-T0)：三組間具統計顯著差異，χ^2(2, N=18)=8.28，*p*=.016，事後比較顯示 VR+SMR 組顯著高於控制組 (*U*=2.50, *z*=-2.66, *p*=.008)，而 VR-Only 組與對照組相比則有邊

緣顯著性 (U=5.00, z=-2.33, p=.020)。於前測與追蹤 (T2-T0) 之間的改變量上，三組間亦具統計顯著差異，χ^2(2, N=18)=8.67，p=.013，事後比較顯示 VR+SMR 組顯著高於控制組 (U=2.50, z=-2.66, p=.008)，而虛擬實境組與控制組則無差異 (U=12.50, z=-1.35, p=.176)。三組別週末運動時間的改變量，後測與追蹤 (T2-T1) 之間並未達組間統計顯著差異，χ^2(2, N=18)=4.79，p=.091。

表 3

主要結果評量-運動參與之改變量、原始數值及組間比較

	VR+SMR (n=6)	VR-Only (n=6)	Control (n=6)	
（單位:小時）	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	*p* value
平日-運動參與				
T0	1.50 (0.71)	0.67 (0.82)	0.92 (0.20)	-
T1	1.92 (0.92)	1.25 (0.99)	1.00 (0.32)	-
T2	1.83 (0.82)	0.75 (1.17)	1.00 (0.32)	-
T1-T0	0.42 (0.74)	0.58 (1.43)	0.08 (0.20)	.778
T2-T0	0.33 (0.26)	0.08 (1.56)	0.08 (0.20)	.149
T2-T1	-.08 (0.59)	-0.50 (0.55)	0.00 (0.00)	.208
週末-運動參與				
T0	1.00 (1.67)	0.67 (1.21)	1.75 (1.29)	-
T1	3.17 (2.14)	2.17 (2.40)	1.58 (1.16)	-
T2	2.83 (2.32)	1.33 (1.75)	1.67 (1.21)	-
T1-T0	2.17 (1.72)	1.50 (1.64)	-0.17 (0.41)	.016*
T2-T0	1.83 (1.72)	0.67 (1.63)	-0.08 (0.20)	.013*
T2-T1	-0.33 (0.52)	-0.83 (1.17)	-0.08 (0.20)	.091

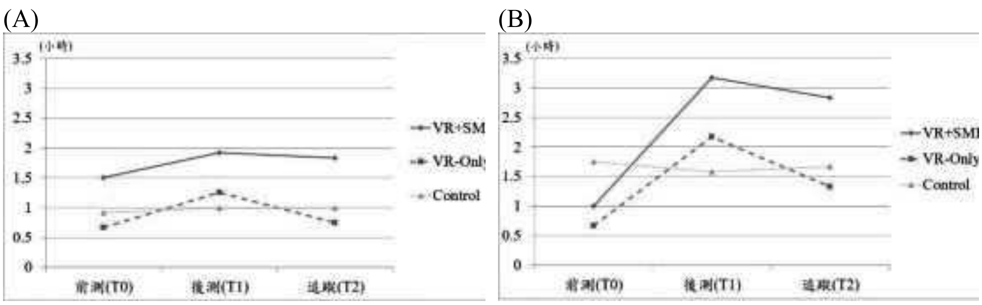

圖 3

三組別運動參與時間（小時）。(A) 為平日，(B) 為週末

在次要結果評量上，三組別在平日與週末的工作、日常活動、休閒娛樂與休息時間使用改變量上，於前測、後測與追蹤時的變化量皆無組別間顯著差異（表 4）。

表 4

次要結果評量-職能活動問卷之改變量、原始數值及組間比較

	VR+SMR (*n*=6)	VR-Only (*n*=6)	Control (*n*=6)	
(單位:小時)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	*p* value
平日-工作				
T0	3.25 (1.92)	2.92 (1.72)	3.83 (1.51)	-
T1	4.17 (1.97)	3.25 (2.27)	3.67 (1.60)	-
T2	5.08 (2.84)	4.50 (2.65)	3.50 (1.48)	-
T1-T0	0.92 (1.11)	0.33 (0.98)	-0.17 (0.41)	.112
T2-T0	0.92 (1.86)	1.58 (1.66)	-0.33 (0.52)	.093
T2-T1	1.83 (2.70)	1.25 (1.75)	-0.17 (0.41)	.170
平日-日常活動				
T0	5.08 (1.32)	6.25 (2.21)	5.83 (1.57)	-
T1	5.17 (1.21)	5.17 (1.44)	5.75 (1.54)	-
T2	5.08 (1.53)	5.17 (1.44)	5.58 (1.43)	-
T1-T0	0.08 (0.49)	-1.08 (1.77)	-0.08 (0.20)	.204
T2-T0	0.00 (0.55)	-1.08 (1.74)	-0.25 (0.42)	.382
T2-T1	-0.08 (0.38)	0.00 (0.55)	-0.17 (0.41)	.654
平日-休閒娛樂				
T0	5.42 (2.44)	3.83 (2.81)	4.92 (1.07)	-
T1	4.75 (1.57)	5.50 (2.17)	5.17 (1.29)	-
T2	4.33 (1.57)	4.67 (1.91)	5.42 (1.36)	-
T1-T0	-0.67 (0.98)	1.67 (2.68)	0.25 (0.42)	.131
T2-T0	-1.08 (2.10)	0.83 (1.57)	0.50 (0.45)	.097
T2-T1	-0.42 (0.80)	-0.83 (1.21)	0.25 (0.42)	.082
平日-休息				
T0	10.25 (1.41)	11.00 (1.41)	9.42 (1.32)	-
T1	9.92 (1.24)	10.08 (1.53)	9.42 (1.32)	-
T2	9.50 (1.26)	9.67 (1.89)	9.50 (1.18)	-
T1-T0	-0.33 (0.82)	-0.92 (0.38)	0.00 (0.00)	.090
T2-T0	-0.75 (1.67)	-1.33 (1.17)	0.08 (0.20)	.132
T2-T1	-0.42 (1.07)	-0.42 (1.16)	0.08 (0.20)	.661

表 4（續）

次要結果評量-職能活動問卷之改變量、原始數值及組間比較

	VR+SMR (*n*=6)	VR-Only (*n*=6)	Control (*n*=6)	
(單位:小時)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	*p* value
週末-工作				
T0	0.00 (0.00)	0.00 (0.00)	0.75 (1.17)	-
T1	0.00 (0.00)	0.00 (0.00)	0.75 (1.17)	-
T2	0.00 (0.00)	0.00 (0.00)	0.83 (1.33)	-
T1-T0	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	.368
T2-T0	0.00 (0.00)	0.00 (0.00)	0.08 (0.49)	1.000
T2-T1	0.00 (0.00)	0.00 (0.00)	0.08 (0.49)	.729
週末-日常活動				
T0	5.08 (1.69)	5.08 (1.60)	5.50 (1.58)	-
T1	4.58 (1.05)	5.00 (1.21)	5.33 (1.47)	-
T2	4.42 (1.02)	5.16 (1.39)	5.17 (1.17)	-
T1-T0	-0.50 (0.97)	-0.08 (0.49)	-0.17 (0.26)	.560
T2-T0	-0.67 (0.98)	0.08 (0.67)	-0.33 (0.93)	.410
T2-T1	-0.16 (0.20)	0.17 (0.41)	-0.17 (0.93)	.490
週末-休閒娛樂				
T0	8.42 (2.99)	7.50 (2.45)	7.25 (1.86)	-
T1	9.92 (2.49)	8.33 (1.89)	7.50 (1.61)	-
T2	9.58 (2.11)	8.26 (1.32)	7.58 (1.53)	-
T1-T0	1.50 (1.05)	0.83 (1.17)	0.25 (0.42)	.064
T2-T0	1.17 (1.29)	0.76 (1.74)	0.33 (0.52)	.391
T2-T1	-0.33 (0.61)	-0.07 (0.76)	0.08 (0.20)	.343
週末-休息				
T0	10.50 (1.73)	11.42 (1.46)	10.50 (1.23)	-
T1	9.50 (1.67)	10.67 (0.88)	10.42 (1.16)	-
T2	10.00 (1.38)	10.58 (0.67)	10.42 (0.97)	-
T1-T0	-1.00 (0.55)	-0.75 (0.88)	-0.8 (0.38)	.078
T2-T0	-0.50 (0.45)	-0.83 (1.21)	-0.8 (0.38)	.304
T2-T1	0.50 (0.45)	-0.08 (0.49)	0.00 (0.32)	.075

討論

本研究採隨機對照試驗，提供初步證據支持虛擬實境健走於慢性思覺失調症個案之可行性，此類活動可讓精障者從事中等到強度身體活動，並且對於週末假日的體能活動參與具有促進作用，而簡訊提醒則可以短暫維持體能參與之成效。過去研究曾以虛擬實境訓練思覺失調症個案就業 (Sohn et al., 2016)、認知 (Chan et al., 2010) 等功能面向，本研究則將該技術用以促進體能活動參與，應用商業化的 App 程式，搭配投影設備產生非沉浸式虛擬實境體驗，並應用於臨床個案。

一、虛擬實境健走之可行性

受試者參與虛擬實境之整體出席率高於九成，研究過程中無受試者退出。近期的隨機對照試驗曾探討以跑步機進行高強度間歇訓練 (high intensity interval training)，發現精神疾患個案在 6 個月的介入期間，共有一半的受試者退出試驗，運動訓練的平均出席率為 64% (Romain et al., 2019)。另一研究應用動機理論以期促進思覺失調症體能活動參與，在 24 週的介入期間，受試者參與團體健走活動的出席率為 34% (Browne et al., 2021)。另一探討有氧運動介入成效的小型隨機對照試驗，讓受試者參與跑步機、健身車與橢圓機訓練，對照組參加肌力訓練，在 12 週訓練過程中的整體出席率為 81% (Bredin et al., 2013)。過去曾有統合分析顯示思覺失調症參與運動介入方案平均退出率為 32.5% (Dauwan et al., 2016)，本研究於 4 週的介入期間，一週 5 次進行虛擬實境健走，與前述使用跑步機、團體健走的臨床試驗相比，受試者於短期內之出席率高且退出率低，且所採用的商業化 App 價格低廉，初步顯示虛擬實境健走活動於思覺失調類群個案之可行性；受試者於 4 週介入期間，可能因感到新奇，於醫院環境內模擬實際戶外環境健走，並有專業人員陪伴等因素而持續參與運動，但此結果仍需謹慎看待，尚無法推論到更長遠之效益。

本研究之虛擬實境健走方案，運動訓練之目標心率係參考 Bredin 等人 (2013) 之有氧運動方案，採漸進式提升運動介入強度。接受虛擬實境健走的受試者 (*n*=12)

之主觀自覺費力指數平均為 5.99 分，屬於強度費力活動；又運動強度達成率為 90.90%，表示虛擬實境健走訓練的順從度良好。顯示本研究所採用之非沉浸式虛擬實境技術，結合二維投影設備與 Google Map 街景，設定住家附近行走路線之健走活動，不論是受試者主觀感受，或以心跳率之客觀評量，皆與過往採用跑步機進行有氧訓練的臨床試驗運動強度相當 (Bredin et al., 2013; Su et al., 2016)，對思覺失調症個案應是一項有效率的有氧運動模式；參與虛擬實境健走之受試者，有部分腳酸、疲累、頭暈之不適報告，許君瑩等人曾以焦點團體探討思覺失調症個案進行 3 個月有氧訓練後的感受，發現精障者參加跑步機訓練時，在前一個月時體力負擔較大，容易出現痠痛不適，直至方案後期可改善（許君瑩等，2017），本研究中參與者之不適反應與過去文獻相似，受試者於適度休息後皆可緩解，並且持續參與到方案結束。

二、虛擬實境健走之介入成效

本研究結果發現虛擬實境，對於受試者平日的運動參與無顯著提升，接受虛擬實境介入的受試者於前後測之間 (T1-T0)，平日運動時間提升約 0.42 到 0.58 小時，代表受試者於平日除了既有的體能活動參與外，另外配合出席 50 分鐘之虛擬實境健走，部分個案於訓練後減少其他體能活動參與，例如：因疲累縮短散步時間，而平日返家後亦未增加動態活動；於後測到追蹤 (T2-T1) 之間，不論有無簡訊提醒，受試者平日運動參與時間改變量少，研究之介入未能使受試者的平日體能參與習慣產生改變，可能原因為介入時間與介入頻率不長，未來研究應增加簡訊提醒的時間與頻率，以瞭解簡訊提醒之成效。

在週末體能活動參與上，虛擬實境健走的受試者於前後測之間 (T1-T0) 參與時間提升約 1.50 到 2.17 小時，VR+SMR 組較控制組顯著提升 (p=.008)，另 VR-Only 組與控制組相比亦有邊緣統計顯著水準 (p=.020)，顯示虛擬實境健走應可促進受試者於週末的體能活動參與。根據職能活動問卷，可歸納出受試者較願意出門散步、外出踏青或是慢跑等。而在後測與追蹤之間 (T2-T1)，三組別的週末體能活動參與時間改變量為-0.83 到 0.08 小時，組別之間改變量未達顯著差異；比較追

蹤與前測 (T2-T0)，VR+SMR 組的週末活動參與時間改變量顯著高於控制組 (p=.008)，但 VR-Only 組之改變量未高於控制組 (p=.176)，綜合前述結果，顯示簡訊提醒未能進一步增加思覺失調症體能活動參與時間，但可協助維持運動習慣，因此簡訊提醒仍是促進精障者之體能活動的可行方式之一。

促進精障者之體能活動參與為臨床介入相當重要之議題 (Stubbs et al., 2016; Vancampfort et al., 2015)，但精障者可能因環境不便利與自我效能低落，而難以於社區參與體能活動 (Chen et al., 2017b; Vancampfort et al., 2012)，虛擬實境可提供思覺失調症個案測試自己能力，並模擬真實世界表現的媒介 (Välimäki et al., 2014)。近期有研討會報告以沉浸式虛擬實境技術，用來促進思覺失調症的生理健康，作者認為虛擬實境可能是改善思覺失調症肥胖、低活動量之有效方法 (Alptekin et al., 2020)。Bredlin 等人 (2013) 採用不同類型之有氧運動訓練持續 12 週，結果顯示受試者在介入後，主觀陳述增加 2.23 倍的中度到高強度體能活動參與時間，於另一項近期於韓國進行的隨機對照試驗，讓思覺失調症個案進行 16 週戶外腳踏車活動，並與劑量相當的傳統職能治療相比較，結果兩組於受試者主觀陳述的體能活動量表上無顯著差異，但戶外腳踏車活動可增加受試者的每日行走步數 (Ryu et al., 2020)；另有研究採用不同的動機促進方式，搭配團體健走活動，介入 16-24 週後可促進思覺失調症參與走路的時間 (Beebe et al., 2011; Browne et al., 2021)。

本研究採用虛擬實境技術，與傳統有氧運動設備、戶外腳踏車、動機促進策略合併健走團體等方法，皆有促進思覺失調症個案體能活動參與之效，而前述研究皆未呈現平日與週末之差異 (Beebe et al., 2011; Bredin et al., 2013; Browne et al., 2021; Ryu et al., 2020)；思覺失調症個案於平日與週末的時間使用應具一定程度之差異，過往研究也發現工作常規會影響思覺失調症之時間使用，即有工作常規時，思覺失調症個案會有較多時間進行工作相關活動，若無工作常規則較常參與靜態活動，如聽音樂、看電視 (Minato & Zemke, 2004)，本研究結果提供初步證據支持虛擬實境健走對於促進週末體能活動參與之成效。

三、簡訊提醒之成效

本試驗於追蹤階段，使用簡訊提醒鼓勵受試者持續參與運動，結果顯示簡訊提醒未能進一步增加思覺失調症個案體能活動參與，但可維持正向改變的運動習慣，與過往使用簡訊提醒促進精障者參與體能活動的研究結果相似 (Chen et al., 2017a; Naslund et al., 2016) 。Chen 等人 (2016) 在思覺失調症的八段錦團體介入後，使用簡訊提醒、發放手冊、錄製光碟等方式促進體能活動習慣，結果顯示受試者對簡訊提醒的接受度高，並且協助受試者在家繼續運動，然該研究未採用對照組，本研究則採取更嚴謹之研究設計，探討於追蹤階段單獨使用簡訊提醒之效益，並且結果支持簡訊提醒可維持週末體能活動參與。過往研究曾指出社交孤立 (Vancampfort et al., 2012)、缺乏家人與朋友支持 (Chen et al., 2017b)是思覺失調症個案參與體能活動之阻礙，而專業人員之參與、社交支持 (Chapman et al., 2016) 為促進因子，因此簡訊提醒可作為專業人員遠距參與及提供思覺失調症個案社交支持之媒介。

四、整體介入成效與研究限制

本研究的次要結果評量顯示研究介入對於思覺失調症的平日與週末各項職能生活參與無顯著差異。於前測時，受試者平日（平均 9.42 到 11.00 小時）與週末（平均 10.50 到 11.42 小時）仍有較多時間用於休息、靜態活動或睡覺，與過往研究報告結果相當 (Cella et al., 2016; Stubbs et al., 2016) 。而在研究介入後，受試者平日之日常活動、工作參與、休閒娛樂與休息之時間使用未有顯著改變，推測平日個案於日間留院，返家後時間接近夜晚，案主仍習慣維持既有生活習慣有關。於週末的時間使用上，研究介入後受試者在日常活動、工作參與、休閒娛樂與休息的時間分配未有顯著改變，然而在休閒娛樂活動參與上，VR+SMR 與 VR-Only 組的受試者將較多靜態休閒娛樂活動，例如手機上網、看電視，改為外出散步、出門運動、與家人戶外走走等動態休閒娛樂。

本研究有許多限制，如以下討論：(1) 本研究為小樣本數之先驅試驗，研究結果仍需謹慎看待之。(2) 本研究於單一臨床單位，徵招對象多為日間留院慢性思覺

失調症個案，研究結果尚無法類化至其他病程、不同屬性之個案。(3) 受試者與提供介入者，未能進行盲化 (Blinding)，然而多數非藥物研究皆有此限制 (Boutron et al., 2008)，本研究中之可行性評估如:心跳率，以客觀之儀器進行評量，可減少表現偏誤 (performance bias) 之風險；然時間使用評估為受試者自填故可能有表現偏誤之風險，運動時間為作者分析與計算，未來可採運動手環、腕動儀等客觀評估工具檢驗之。(4) 本研究之虛擬實境介入期間為 4 週，簡訊提醒與追蹤亦為 4 週，故無法推斷更長時間的效益。(5) 本研究虛擬實境設備中，使用商業化軟體投影 Google map 街景圖示，其顯示的圖示多為汽車車道攝影畫面，對於部分馬路與街道，其健走畫面與人行道尚有差異，此技術限制仍尚待克服。(6) 本研究並未記錄受試者簡訊讀取率、回傳率等資訊，因此對於簡訊提醒之成效，仍需更嚴謹之研究設計驗證之。未來研究可以更大樣本進行驗證，並探討更長時間的虛擬實境健運動之效益，追蹤更長時間的成效；在結果評量上，除了應用新型體能活動監測設備外，也可評估精神症狀、體適能、生活品質等結果，並可採取評估者設盲以增進研究之內在效度，此外，也可就受試者基本特徵，例如罹病時間、居住狀況等變項，與介入成效進行分析探討，以進一步了解不同受試者特徵與介入成效之關聯性。

結論

本研究提供初步證據，支持採用商業化 App 結合 Google Map 街景圖示的非沉浸式虛擬實境健走活動於慢性思覺失調症個案之可行性，該類活動可達中等到強度身體活動，並且受試者順從度佳。於成效上，研究結果顯示虛擬實境健走可增加思覺失調症個案於週末參與體能活動的時間，並且在追蹤階段使用簡訊提醒，可以維持此改變。然而，本研究尚有許多限制，臨床工作者仍須謹慎看待此初步結果，並待後續研究進一步驗證。

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Original article

Application and Efficacy of Virtual Reality and Short Message Reminders in Patients With Schizophrenia: A Pilot Trial

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Abstract

To improve physical activity participation in patients with schizophrenia is a crucial challenge. Emerging technologies such as virtual reality (VR), information and communication technology may provide additional benefits to conventional regimens. The purpose of this study was to explore the feasibility of VR walking activities, and their effects on time use among patients with schizophrenia. We also explored the efficacy of short message reminders (SMR). A pilot randomized controlled trial was conducted with 18 participants being randomly assigned to the VR walking activities with short-message reminders (VR+SMR), VR walking activities only (VR-Only), or control groups. The VR+SMR and VR-Only groups attended virtual reality walking activities 5 times/week, 50 minutes/session for 4 weeks. Controls received casual walking with the same dosage. The VR+SMR group received additional short-message reminders in the follow-up period. The results indicated that the overall attendance rate of VR walking activities was 96.25%, with 90.90% of sessions achieved the predetermined target intensity. There were significant differences on change of exercise participation on weekends among groups at posttest (p=.016) and follow-up (p=.013). Compared to control group, *post hoc* analyses revealed a significant difference in exercise participation on weekends favored VR+SMR group (p=.008) and marginal significance favored VR-Only group (p=.020). At follow-up, the VR+SMR group remained significantly larger change in exercise participation on weekends than the control group (p=.008). The results support the feasibility of VR walking activities, and their efficacy in exercise participation on weekends in patients with schizophrenia. Short-message reminders may maintain the behavioral change on physical activity participation.

Keywords: *Health Promotion, Schizophrenia, Short Message Reminder, Time Use, Virtual Reality*

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原著

駕駛模擬器於青壯年中風患者進行駕駛訓練成效之初探研究

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摘要

使用駕駛模擬器作為駕駛復健的評估與訓練是目前職能治療的新興領域。模擬科技的導入可提供安全且擬真的方式進行道路駕駛體驗，並以人機高度互動回饋學習模式，增加駕駛者學習動機與自我能力的後設認知。本研究的目的為透過模擬駕駛課程的訓練，了解青壯年中風患者在接受課程後的經驗與後續 3 個月追蹤。共有四位青壯年中風患者參與本研究。受測者在接受一般門診治療後，額外再接受為期 3 週，每週 3 堂，每堂 30 分鐘的模擬駕駛訓練課程。模擬駕駛訓練課程包括六種不同駕駛情境，每一情境受測者至少要完成一堂課程。3 週課程結束後，受測者接受半結構性問卷調查以收集質性意見，並於 3 個月後電訪了解是否有回歸自行駕駛行為。結果顯示課程結束後受測者駕駛反應時間有顯著改善 (p<.01)，且模擬駕駛器能讓受測者體認到自身安全駕駛能力的不足處。三位受測者有回歸自行駕駛，且未有發生交通事故，一位則主動放棄自駕行為。駕駛是高度雙重任務的職能活動，模擬器可評估駕駛者潛在的危險駕駛行為。本研究建議除了基本的動作感覺的臨床評估之外，搭配選用合宜的不同評估工具組合構成一完整駕駛評估模組，才能真實反應出駕駛者的自身能力。

關鍵字：駕駛復健，中風，後設認知

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前言

腦中風為長居於台灣 10 大死因的第 2-4 位，僅次於各種癌症之總和及心臟疾病，然而現在腦中風也逐漸呈現了年輕化趨勢。過去文獻界定腦中風患者若年紀少於 45~49 歲以下者，稱之為青壯年中風 (Smajlović, 2015)。其發生率在西方國家估所有中風族群約為 5~10 % (Nencini et al., 1988)，在發展中的國家則可能達到 19 to 30 % (Radhakrishnan et al., 1986)。然而因現今醫學科技的已有十足進步，加上年紀輕者預後較佳，青壯年中風患者通常經由持續復健治療可達到相當程度的自主獨立生活。此類患者比老年患者有更長的餘命，加上該年齡層的職能角色大多為經濟生產者，因此雖有不錯的復健效果，殘餘的生理動作或認知障礙仍然會影響到其職能角色的扮演。

近幾年來，世界衛生組織發展出「功能、失能、和健康之國際分類」(International Classification of Functioning, Disability, and Health, ICF) 架構，以「健康功能」的觀點來代替原來對障礙的定義，將原本損傷 (impairment)、障礙 (disability)、殘障 (handicap) 模式轉變為身體功能與構造 (body functions and structures)、活動 (activities)、參與 (participation) 模式，並且強調環境和個人因素對個體的影響，認為「社會限制」和「環境阻礙」會影響個體的障礙程度，而非只是從其本身的障礙狀況來做探討 (World Health Organization, 2001)。職能治療專業的中心信念是任何人不論本身的障礙程度，都應該能夠參與對他而言有意義，符合他的需求及選擇的職能活動。汽車駕駛為一重要職能活動，它不僅提升了個人外出的自由度與彈性，駕駛者也可載朋友或家人外出購物、就醫、旅遊、拜訪他人、上班或上學；這不僅滿足了自己與他人生活、工作或就學、娛樂上的需求，駕駛可以說是與社會維持連結和社會參與的重要橋樑 (Dickerson et al., 2007) 。在臨床上當青壯年中風患者，雖其生理動作或認知仍有不便處，但希望能夠重拾原駕駛職能，以方便使用汽車作為回歸職場的交通工具。此時，職能治療師的角色則應協助評估其感覺、動作與認知能力、駕駛表現的程度、及訓練補強不足處 (Stav et al., 2010) 。另先前研究亦指出有大多數中風患者不自覺自身能力不足，已經再不適合繼續安全駕駛 (Patomella et al., 2008) ；因此職能治療師有必要協助此類患者

認知且正視自身駕駛能力的不足，進而考慮主動放棄自己駕駛意願，改採用其他交通方式（如：搭乘他人所駕駛車輛或公共運輸工具）。

美國、加拿大、澳洲、紐西蘭等國家將駕駛評估及治療列為職能治療的專業範疇已行之有年，並設有次專科制度，例如透過一年半到兩年的訓練，職能治療師可成為駕駛復健專家 (driver rehabilitation specialist) ，可與汽車駕駛教練、及其它專業人員合作，專職高風險駕駛者評估及處置（張玲慧等，2016）。一般而言，適性駕駛評估 (fitness-to-drive) 的第一步驟為生理功能狀態的臨床評量，確認駕駛者具有符合駕駛體檢通過的要求 (Unsworth, 2007) ，第二步驟則為綜合性的駕駛評量 (comprehensive driver evaluations) ，這包括非道路駕駛 (off road) 評量與道路 (on road) 駕駛評量，其評量結果可分為通過、不通過、與建議接受駕駛復健課程 (Classen et al., 2009; Unsworth et al., 2011) 。若個案經過適性駕駛評估後，倘若足以推論接受適當的駕駛相關行為訓練介入後，有潛力能達到安全駕駛行為者，則推薦個案可接受駕駛復健課程 (Unsworth, 2007) 。而職能治療師則在這類身障者或高齡長者適性駕駛評估、駕駛復健訓練介入計畫的制定與執行扮演極重要的角色 (Pellerito, 2006; Redepenning, 2006)。

國外研究紛紛指出適性評估中風患者回歸駕駛行為 (driving behavior) ，最好要有擬真駕駛情境，包括實際道路駕駛測試 (On-Road driving test) 或駕駛模擬器 (Driving simulator; Akinwuntan et al., 2005; Akinwuntan et al., 2003; Akinwuntan et al., 2002; George et al., 2014)，其中實際道路駕駛測試被認為最能反應出駕駛人的能力表現。然而實際道路駕駛測試若擴大實施於所有身障者，不僅需要投入的大量人力、物力資源，且在實際道路測驗路線上，可能會對於其他使用道路之行為人產生危險（如：路線經過市區中心）。據此、非實際道路駕駛評估的工具已廣泛提出使用，例如: 非動作視知覺測驗 (Motor-Free Visual Perception Test, MVPT) ，路徑描繪測驗 (Trail Making Test, TMT) 等，評估結果可用來推估駕駛能力的表現（張玲慧等，2016）。但過去文獻回顧研究也發現單一評估工具的預測結果是仍不足以反應出駕駛行為表現，建議採用測驗模組方式，將有用或相關的評估工具組合成一駕駛評估模組，來進行綜合評估才能完整反應出駕駛能力 (Dickerson et al., 2014; Fields & Unsworth, 2017; Rashid et al., 2020) 。除了上述的標準化評估工具外，駕

駛模擬器因具有擬真效果、不需花費太多人力物力資源即可達到客觀評估真實的道路駕駛狀況 (Lew et al., 2005) ，甚至可以使用駕駛模擬器讓來訓練中風患者駕駛，並從旁給予互動回饋，藉由模擬器之主動駕駛體驗訓練，能有效提升真實道路駕駛的表現 (Akinwuntan et al., 2005; Classen & Brooks, 2014; Devos et al., 2009; Imhoff et al., 2016; Unsworth & Baker, 2014) 。故本研究目的嘗試引用駕駛模擬器，並透過模擬駕駛訓練課程的實驗與訪談，了解青壯年中風患者在接受模擬駕駛課程後的初步成效與經驗與後續追蹤，做為開啟日後國內相關駕駛復健研究的參考，盼能引導職能治療從業者重視這類議題。

方法

一、受測者

本研究採取方便取樣方式招募受測者。中風受測者符合下面收案條件使納入為受測者： (1) 目前仍持有合格小型汽車普通駕駛執照且未因交通違規而吊銷其駕駛執照； (2) 不借助輔助器具或人力等外力，能自力行走者； (3) 通過交通部公路總局所公告之「認知功能測驗」（交通部公路總局，2017）； (4) 通過線段中分測驗 (Line Bisection Test; Schenkenberg et al., 1980) ，並無出現半側忽略 (hemineglect) 現象者。此外，若參與者即使符合收案條件，但有下面排除條件亦排除參與研究：(1) 曾有嚴重動暈症狀 (motion sickness) 病史者；(2) 有視覺障礙，經矯正後兩眼視力未達 0.8，且每眼各達 0.6 者； (3) 有診斷梅尼爾氏症病史。本研究施測流程已經通過高雄醫學大學附設中和醫院「人體試驗委員會」審核准許實施 (KMUHIRB-E(I)-20190085) 。受測者皆在充分告知施測流程、本身的權益與資料保密原則，並簽署受測者同意書後，始開始進行施測。

二、研究流程

（一）模擬駕駛系統

本研究採用 Carnetsoft 汽車模擬駕駛系統 (Carnetsoft BV, Groningen, NL) ，該系統包括高效能電腦、三面 29 吋 HDMI 液晶螢幕顯示器組合成一環繞全景來提供視覺回饋、擬真駕駛座（含油門與煞車踏板），及 14 吋方向盤（如圖 1 所示）。駕駛椅座如同汽車椅座一樣，可配合個案腿長調整坐深，以便腳底踏踩油門與煞車踏板。因國內車輛駕駛座為靠左設計，所以油門與煞車踏板皆比照實際駕駛座設計，置於靠右側腳底。排檔桿則置於右手處，具有手排與自排控制功能，皆可透過排檔桿進行升降檔或倒車檔，以符合駕駛最熟悉的排檔使用方式。

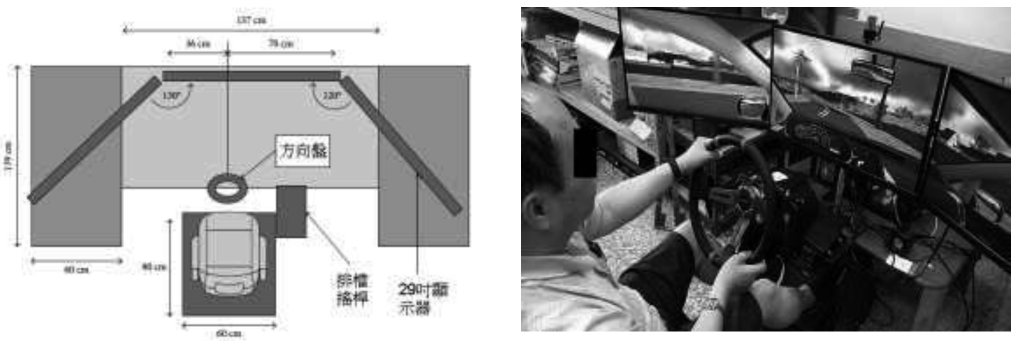

圖 1
Carnetsoft 汽車模擬駕駛系統。左邊為硬體設備佈置圖，右邊為受測者駕駛操作示範圖

汽車模擬駕駛系統可模擬 29 組不同情境的駕駛環境，如：郊區/市區道路駕駛、高速公路駕駛、夜間/雨天駕駛等。經過與受測者討論後，他們指出駕駛需求是以能夠日間就近在住家郊區平面道路開車為最優先，且因受測者能夠參與的時間有限，無法逐一完成所有模擬駕駛情境，所以研究者選用下面六個基本的情境作為本研究駕駛訓練課程： (1) 基本汽車操作（含：油門與煞車、自動排檔、左右方向燈、頭燈與雨刷使用）； (2) 直行駕駛； (3) 交叉路口左右轉； (4) 郊區道路駕駛； (5) 綜合性駕駛練習； (6) 倒車練習。受測者在進行每堂駕駛訓練課程之前，一位研究者會先解說該堂課的駕駛學習目的及應注意的安全駕駛規則（如：

轉彎車應讓直行車先行、轉彎時應距交岔路口三十公尺前顯示方向燈，駛至路口後再行左右轉）。系統軟體本身也會主動提醒任何違規事件（如：未打方向燈、偏離車道、未到交岔路口提早轉彎、超速等）並紀錄次數。因此研究者可從駕駛訓練課程違規次數來了解受測者出現危險駕駛行為的頻率。此外，該系統軟體亦提供一單獨測驗單元用來測量駕駛反應時間，在此測驗單元受測者將駕駛在一道路上（非完整筆直有彎道的路況），加速並維持在 100 公里/每小時時速後，螢幕不定時顯示一停止標誌，當受測者看到停止標誌時，應立即踏踩煞車直到完全停止，並由電腦記錄從出現停止標誌到完全停車所花費時間，共進行五次測試取其平均值，做為駕駛反應時間之數據。研究者在開始進行訓練課程前與結束課程後，分別記錄受測者的駕駛反應時間，以作為訓練效標。

（二）模擬駕駛課程

受測者在接受一般門診職能治療後，額外再接受 3 週每週 3 堂每堂 30 分鐘的模擬駕駛訓練。在進行每堂駕駛訓練前，研究者會與受測者討論他當天想學習的課程內容，並就之前課程學習的效果，共同來決定是否再次重覆上次的課程內容或者是進入下個課程內容，但上述六個駕駛訓練情境皆要參與且至少需要上過一堂。每堂課結束後研究者會就受測者的駕駛表現給予回饋並給予適當居家自我復健的活動（如：腳跟著地提高腳背，進行足踝關節背曲伸展動作，以降低小腿後側肌群異常張力；連續性腳底板原地左右交互點踏運動等）。在整體 3 週課程結束後，受測者會接受半結構性問卷調查，由第三方非擔任駕駛訓練的研究人員透過與受測者個別一對一面談，了解及接收訊息，並收集到受測者對於課程自我主觀感受資料，例如：在模擬課程中是否有自覺留意到駕駛失誤的次數？模擬駕駛環境的擬真效果如何？模擬駕駛過程中是否會出現頭暈噁心不適感？模擬課程對自己回歸駕駛的幫助性為何？三個月後，研究者會再進行電訪詢問受測者是否有回歸駕駛職能活動，及是否有因此發生任何交通違規狀態。

三、統計分析

使用描述性統計了解受測者選擇課程堂數，及該課程平均發生違規事件次數。此外，為了比較受測者在接受模擬駕駛訓練課程後，駕駛反應時間的差異性，以無母數統計中之魏克生符號檢定 (Wilcoxon signed-rank test) 方法，來檢定的差異，顯著水準 α 設為 0.05。所有資料皆使用 IBM SPSS 21.0 Statistics for Windows 套裝軟體 (IBM Corp., Armonk, NY) 進行相關統計分析。

結果

共計有 4 位男性中風患者（三位為左側大腦中風、一位為右側大腦中風）自願同意參與本研究，平均年齡為 41.4±2.8 歲，平均中風病史為 14.2±5.6 月，過去駕駛經驗平均為 15±7.2 年。圖 2 為受測者選擇模擬駕駛訓練課程的單元上課平均比重，四位受測者在選擇各單位的上課比重差異性不大，基本汽車操作與直行駕駛皆被認為只要上一堂就可以，兩個單元共佔課程比重 22%，然而交叉路口左右轉、郊區道路駕駛、綜合性駕駛練習、倒車練習皆是被認為需要重複性練習的課程。同樣地，在課程單元平均發生違規事件次數，依高低發生順序為郊區道路駕駛、綜合性駕駛練習、交叉路口左右轉、倒車練習、基本汽車操作、直行駕駛（如圖 3 所示）。在駕駛反應時間上，經過 3 週九堂模擬駕駛訓練課程後，其平均反應時間有顯著性的縮短 ($p<.01$) ，從 113.5±30.4 秒進步到 83.5±23.5 秒，其中有兩位受測者分別進步差異達到 40 秒與 43 秒之多。

在質性訪談意見上，4 位受測者在中風之前皆因工作需求，每週至少有五天需自行開車出門，但中風後就沒有開車。在尚未皆受模擬駕駛訓練課程前，4 位受測者本身的狀態皆能獨立行走，伸手取物皆無任何困擾，故自認有本身足夠的能力回歸駕駛活動。然而經過訓練課程後，受測者皆表示模擬駕駛課程確實會讓自己了解到自身能力不足處（如：不自覺跨越車道駕駛、忽略左右邊來車、一邊打方向盤一邊踩油門時出現手腳不協調現象）。模擬駕駛環景所呈現內容雖然不能像真實環境一樣逼真，但也能體驗到道路駕駛的經驗（如：對向來車、判斷前車距離），不像一般電玩遊戲強調快速、碰撞、趣味為主體驗。此外有兩位受測者亦指出長時

間連續模擬開車，在結束後會出現暈眩伴隨噁心的情況，但在適當休息後症狀會消失。最後有三位表示課程結束後，會找資源自已練習開車，一位自認表現還不錯，但在旁陪伴之家庭成員照顧者明顯感受到個案危險駕駛的行為，表示會勸阻個案自行開車。三個月後的電訪顯示有兩位目前有經常自行駕駛汽車（一週超過三天會開車），一位偶爾會自行駕駛（一週少於三天會開車），另一位則放棄自行駕駛汽車，改搭乘其他交通工具。有自行駕駛行為者截至電訪日期為止，皆未反應有發生任何與自駕所導致的交通事故。

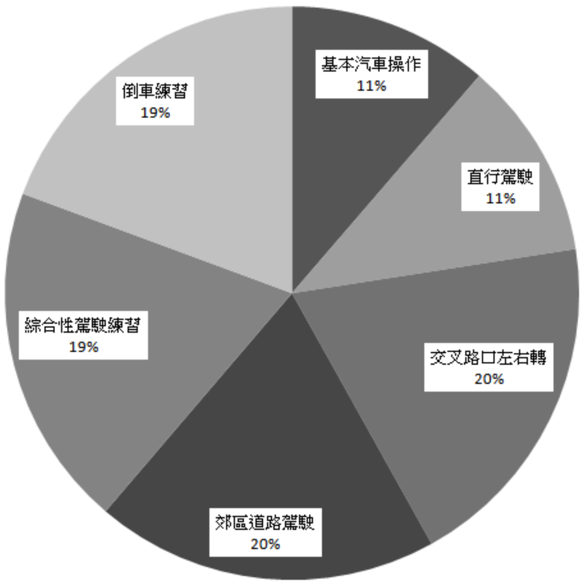

圖 2
六個模擬駕駛單元所佔之課程百分比

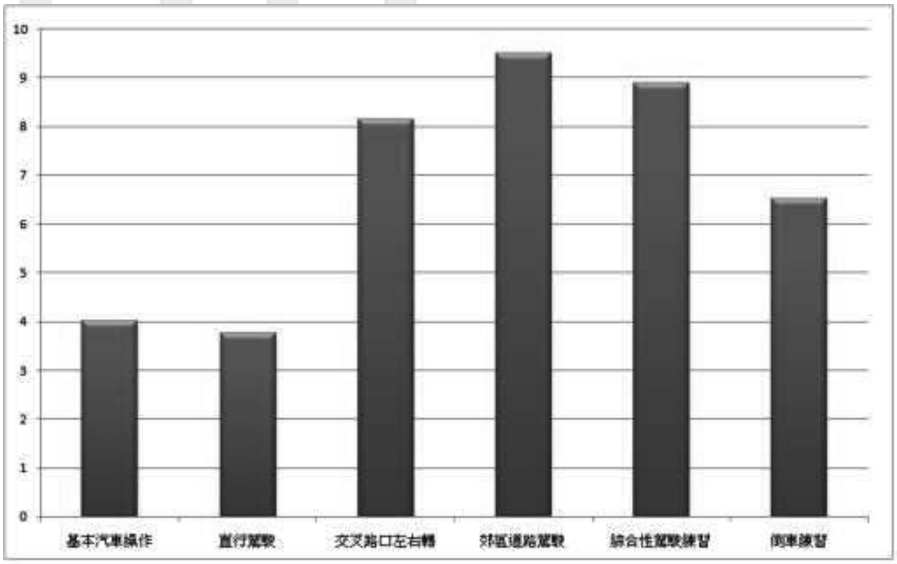

圖 3
各課程單元平均發生違規事件次數

討論

本研究就輕度障礙的青壯年中風患者進行模擬駕駛訓練課程，結果顯示受測者在駕駛反應時間上有顯著的進步，且模擬駕駛課程確實能讓受測者體認到自身安全駕駛能力的不足處。因中風、腦部外傷或任何原因之腦部傷害的輕度損傷患者，雖然在生理身體功能上透過積極地復健治療，可以達到生活自理，獨立行走能力；不過腦部傷害所造成的認知功能損傷，包括：問題解決困難、視覺處理速度緩慢、需要較長之反應時間、判斷困難、記憶問題、自我覺察問題、對於時間／地點／情境之混淆現象等後遺症，都有可能導致安全駕駛問題。Michon (1985) 便提出駕駛任務可視為三層連續認知控制的階級模式 (hierarchical mode) ：(一)、策略層次 (strategic level)，例如規劃交通路程動線；(二)、戰術層次 (tactical level)，例如基於交通路況來判斷是否通過路口、加減車速等；(三)、操作層次 (operational level)，例如即時控制方向盤或腳踩煞車 (Michon, 1985) 。其中駕駛者的人格特質會主要影響到策略層次與戰術層次，因為駕駛者往往會依據自己的情緒狀態、偏好或習

慣來事先規劃駕駛動線或更改路線 (Hatakka et al., 2002)；而駕駛者認知能力則會主要影響到戰術層次與操作層次的判斷，因為駕駛者需要依交通路況進行適當的判斷並執行正確駕駛操控行為 (Sommer et al., 2008)。據此 Sommer 等學者 (2010) 指出中風患者認知能力表現，對於預測能否適性駕駛是非常重要的指標。雖然輕度認知功能損傷者被認為可以安全駕駛，但是認知損傷仍有個別差異，且安全駕駛是需要高度注意力、快速反應與認知能力之雙重任務 (dual tasks)，所以針對此類患者駕駛評估則需要更貼近實際駕駛的評估方式，才能真實反應出患者駕駛行為是否能符合安全駕駛。

本研究的輕度中風受測者在接受模擬駕駛訓練前，皆自認能夠完全回歸至中風前原駕駛操作能力上，但在使用駕駛模擬器進行駕駛訓練課程中，才逐漸自覺體會到自己本身能力上的不足處。McKay 等學者們 (2011) 研究指出中風患者對於自我駕駛能力確實有高估自我能力的現象，透過駕駛模擬器可以讓中風患者在安全環境下，促進患者對本身缺損的自覺認知 (impaired self-awareness) 。研究者在本研究過程中便觀察到即便在直行駕駛狀態下，患者會不自覺偏離車道，或者忽略交通標誌與號誌燈，而直闖交叉路口。倘若駕駛情境逐漸複雜化，例如增加路口左右轉、道路蜿蜒崎嶇時，受測者往往可能反應能力不及出現無法即時煞車，或者認知判斷錯誤，無法正確操作方向盤的方向。從本研究中的綜合性駕駛練習、郊區道路駕駛、交叉路口左右轉課堂內容的違規事件次數激增現象，便可佐證此現象。Hird 等學者 (2015) 亦採用模擬駕駛器進行類似的研究，結果指出輕度中風患者可勝任基本的駕駛活動（如直行或轉彎），但隨著駕駛情境逐漸複雜，其駕駛失誤會顯著上升。然而本研究受測者皆表示這些危險駕駛行為當下並無意識到，直到當天課程結束給予回饋時，才恍然大悟本身有出現這些行為。

本研究有三位左側大腦中風受測者皆反應在進行模擬駕駛時，本身右腳會出現找不到煞車踏板位置的現象，出現誤踩油門或踩空的情況。這推斷與患側右腳腳底的本體感覺不佳有關；另外在高度緊張狀態下，小腿後側肌群張力可能急速誘發上升 (Bhimani et al., 2012) ，導致腳踝背屈活動度不足，無法維持腳尖順利游移在煞車及油門踏板之間。此現象雖不足以影響獨立行走功能，然而在汽車駕駛上卻是十分危險；在後續三個月後的電訪調查結果顯示有一位左側大腦中風受測

者放棄自我駕駛，該個案表示右腳經常會踩不到煞車而感到害怕是讓他放棄駕駛的原因之一。相反地，本研究中右側大腦中風受測者並無出現腳踩煞車踏板的問題（因右腳為健側腳具有完整控制能力），但卻常會忽略到左右來車的問題。過去研究也發現左右側大腦中風患者在駕駛過失型態上會有所差異 (Park, 2015; Shimonaga et al., 2021)，其中發現右側大腦中風患者在駕駛相關的視覺掃瞄 (visual scanning)、視覺建構能力 (visuoconstructive) 、與分散性注意力 (divided attention) 表現上遠不如左側大腦中風患者 (Devos et al., 2014)，因此建議針對不同側大腦中風患者需要特定且不同的駕駛評估和訓練計劃 (Devos et al., 2014; Mazer et al., 2003; Park, 2015)。

目前已逐漸有些生理疾病患者（如：腦傷、中風患者或脊髓損傷患者）求助於職能治療，希望進行適性駕駛評估或者相關訓練。但就現有法規規範上，並沒有針對身心障礙者或其他醫學狀況的駕駛者進行適性駕駛評估，僅在「身心障礙者報考汽車及機車駕駛執照處理要點」明確列出獲得駕駛執照時應符合之體檢規定及是否能使用改裝汽機車報考駕駛執照。然而在《身心障礙者報考汽車及機車駕駛執照處理要點》第 13 條已經明確規定「身心障礙者報考汽車及機車駕駛執照，除下列情形外，應由公路監理機關視情況需要邀請經中央衛生主管機關評鑑合格之醫療院所骨科、神經內外科、復健科專科醫師、職能治療師或其他科別專科醫師組成鑑定小組辦理鑑定：（一）使用一般車輛報考駕駛執照者。（二）使用加裝輔助輪報考機車駕駛執照者。（三）於方向盤加裝握球或扣環報考小型車駕駛執照者。公路監理機關處理身心障礙者報考汽車及機車駕駛執照之申訴案件，得依個案情形組成鑑定小組辦理，並得邀請身心障礙者團體參與、協助。」依該條所述，職能治療師已被納入鑑定小組成員之一，這已凸顯出職能治療從業者在適性駕駛評估領域的重要角色。臨床職能治療師可針對有駕駛汽車/摩托車需求且擁有駕照者，先進行臨床評量/訓練駕駛者的視知覺、本體覺、肢體動作、肌力、認知、以及手腳協調度，以確定駕駛者具備駕駛汽車所需要之基本能力，再搭配選用合宜的評估工具組合（如：TMT、MVPT 與駕駛模擬器）構成一完整駕駛評估模組，才能真實顯示出駕駛者自身能力缺損處。然而此類駕駛議題在國內研究與專業養成教育尚未普及，若能跨領域與資訊相關學科合作，共同開發相關駕駛模擬器，提供安

全有效的評估工具來進行「適性駕駛評估」並且培育駕駛復健的專業人才，也是職能治療服務領域的新拓展。

使用駕駛模擬器雖然可評估駕駛者的操作方向盤技巧、油門與煞車的使用、遵循標誌與號誌燈的能力、控制速度的能力及危機處理的能力等，但模擬之駕駛情境不一定符合每個地區，且與真實駕駛感覺仍有不同。因此，若經駕駛模擬器評量結果，駕駛者具備相當駕駛能力的話，可建議在駕駛訓練機構的安全環境（如駕駛訓練場地）下進行接受汽車駕駛教練指導，以真實交通工具進行駕駛技巧訓練及實際道路駕駛，逐漸重拾駕駛的職能活動。

本研究雖是作為先驅性的研究來探討青壯年中風患者在接受模擬駕駛課程後的經驗與後續追蹤，但仍有許多不足之處，以下將研究困難與限制提出說明，以提供後續研究方向之參考。首先、基於設備資源有限，本研究所採用之汽車模擬駕駛系統並無法提供各課程單元過程中，駕駛行徑軌跡與煞車時間等更詳細的參數來提供後續的研究分析；其次、研究受測者未同時接受其他常用適性駕駛的認知工具評估，如：路徑描繪測驗 (Devos et al., 2011; Marshall et al., 2007; Mazer et al., 1998)、非動作視知覺測驗 (Korner-Bitensky et al., 1998; Mazer et al., 1998)、中風患者駕駛評估 (Stroke Drivers Screening Assessment; George & Crotty, 2010; Nouri & Lincoln, 1992)、有用視野測驗 (Useful Field of View test; George & Crotty, 2010; Marshall et al., 2007)，所以無法得知受測者目前認知能力與模擬駕駛器表現之間的關係；未來研究可整合上述的認知功能測驗與模擬駕駛器應用，做更進一步的研究探討。此外、為避免因老化影響駕駛所需之認知功能退化，本研究受測者僅就四位青壯年中風患者，生理功能皆達到幾乎生活獨立的階段，進行調查，因此對於年長者，或不同程度的生理功能障礙中風患者，是否能執行駕駛復健訓練是無法得知；建議未來研究可針對此類課題進行探討，尤其是應用模擬駕駛器於高齡駕駛者族群，讓其察覺到本身能力不足的後設認知 (metacognition) ，進而促進自主駕駛退休 (retiring from driving) 的意願。

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Original article

Effects of Driving Training With a Driving Simulator for Young Adults With Stroke: A Pilot Study

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Abstract

The use of simulator as an assessment and intervention tool for driving is an emerging field in occupational therapy. Simulation technology provides safe and simulated driving experiences. It can increase drivers' motivation to learn safe driving skills and metacognitive awareness through a human–computer highly interactive learning approach. The purpose of this study was to examine the experience of young stroke survivors regarding driving simulation training and their driving behaviors at 3-month follow-up. Four participants took driving simulation training for 30 min/session, 3 sessions/week for 3 weeks, in addition to usual therapy. The training program included six driving simulating scenarios. Participants were asked to complete at least one of each scenario. After completing the 3-week training program, participants received a semi-structured questionnaire. A follow-up telephone interview was conducted 3 months after the training program to check whether the participant returned to driving. The results indicated that participant's driving reaction time was significantly improved after the driving simulation training. The use of driving simulator helped participants recognize their driving limitations. Three participants returned to driving, and they were not involved in any traffic accident so far. One participant voluntarily surrendered his driving privilege. Driving is an occupational activity with high dual-task demands. The driving simulator can be used to evaluate the driver's potentially dangerous driving behaviors. In addition to basic clinical evaluations of motor and sensory functions, an assessment battery comprising useful driving tests is important to reflect the client's real driving abilities.

Keywords: *Driving Rehabilitation, Metacognition, Stroke*

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原著

開發及應用非市售體感遊戲於中風復健之經驗：以 Kinect 與 Leap Motion Controller 設備為例

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摘要

近年來，虛擬實境與體感遊戲等科技設備逐漸被應用在中風患者。本研究介紹本團隊利用 Kinect 與 Leap Motion Controller 所開發的非市售之體感遊戲，與其運用於中風患者的過程與經驗。本研究介紹開發遊戲所需要的概念，包含像是虛擬替身、視聽回饋、遊戲分級等，同時也簡述了器材、系統及實驗結果。本研究共有 30 名中風患者參與，平均年齡為 43.4 歲，平均發病時間為 8.3 個月；缺血性中風者為 25 人，出血性為 5 人。本研究以 Unity 3D 軟體開發六種非市售遊戲，遊戲結合球類、科幻等主題並以提升上肢近、遠端動作功能為主要訓練目標。每位患者接受每週兩次，每次 60 分鐘，至少 10 次的治療。治療師會根據患者的動作表現選擇四種遊戲，每個遊戲參與十五分鐘。完成十次療程後填寫回饋效能與系統評估問卷。多數的患者認為有正向的使用體驗。結果亦發現相較於市售遊戲，非市售遊戲可以依據病患需求選擇難易度與目標動作，更能符合治療需求。本研究並探討在使用此類系統時，有關年齡、場地需注意事項，及分享跨領域研究的經驗。透過本研究的介紹，希望可以帶給臨床職能治療師相關的資訊，使此治療方法有更廣的應用。

關鍵字：體感遊戲，虛擬實境，中風復健

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前言

近年來，臨床上開始使用虛擬實境 (virtual reality) 設備治療中風患者，這些設備可以提升患者上肢的動作能力。虛擬實境治療具有以下特色：第一，虛擬環境可提供低成本的評估與介入 (Dobkin, 2004) ，同時具有聽覺、視覺、本體覺的回饋 (Lee, 2015) ，可在練習時提供更安全與支持的環境 (Rizzo & Kim, 2005) ，進而促進功能性的恢復；第二，虛擬實境可使治療師更容易調整並設定適合的難度；第三、使用虛擬實境可以在醫院或居家環境中提供更豐富的活動選擇，同時彰顯職能治療師所強調的環境的重要性 (Dunn et al., 1994) 。虛擬實境可以分為沉浸式 (immersive) 、非沉浸式 (non-immersive) ，其中沉浸式又依裝置與互動方式的不同而有不同的分類，例如在臨床常使用大螢幕投影 (large screen projection) ，此類型虛擬實境可以結合影像擷取設備，使用者的影像被錄影後，投射於場景中，故可見使用者的影像顯現在螢幕場景中。特色是使用方便無須配戴其他的互動裝置且環場場景可供多人同時使用。此類型虛擬實境可以增加使用者深度知覺，融入感較桌上電腦視窗型高，由於經濟、方便，常用於臨床研究（古芳菱等，2011）。

同時，體感式感測器，像 Kinect 或 Leap Motion Controller 可結合多種復健需求且使用者無需配戴任何設備在身上，十分便利。Kinect 除了應用在電玩領域外，近年來已逐漸與醫療、復健和教育做結合。利用體感遊戲復健有兩種可能的方式：一是直接使用市面上的遊戲軟體，二是針對復健需求自行開發的遊戲軟體。前者的優點是遊戲內容生動活潑，缺點則是遊戲並未針對復健而設計，更遑論針對不同復健需求與復健強度做調整。相反地，後者的優點是可以針對不同復健需求來開發遊戲，缺點則是由於開發遊戲所需的時間人力成本的限制，此類遊戲通常較為簡單且數量不多（陳虔慧等，2015）。

臺北榮總復健醫學部與中央大學共同利用 Kinect 開發出以居家醫療為基礎的 3D 互動式復健系統，提供病患新的復健模式。透過體感與 3D 技術開發的遊戲軟體，讓病人可移動雙手至指定位置，在人機介面下完成復健活動。例如在投籃遊戲中，病人要雙腳站穩訓練下肢力量，雙手高舉到特定的高度與位置，才能順利把球投入籃框。透過此系統，病人可自行在家復健，不必遠赴醫院復健，減輕舟車之苦

和節省醫療資源（林伯鴻等，2016）。綜合以上文獻，體感遊戲結合復健可以應用於中風患者的復健治療，本研究團隊於數年前開始開發復健用之體感遊戲，並於2019 年 9 月成為正式的自費醫療項目，投入第一線臨床服務，本研究將介紹本團隊開發非市售遊戲的相關過程、使用的裝置、遊戲設計元素及實際應用經驗，希望透過本篇研究的內容，讓有意投入開發的職能治療師得以參考。

方法

一、遊戲設計基本概念與元素

（一）回饋

本系統分為粗大動作與精細動作，粗大動作以 Kinect 驅動，以肩膀、軀幹位置為主要偵測的部位。精細動作則是以 Leap Motion Controller 掃描手掌骨架。遊戲架構以上肢動作結合認知功能的任務為主軸。產出六種遊戲，融合球類、科幻、時鐘等元素，皆以動作學習為目標。回饋是影響動作學習的一個重要因素。過去文獻中提及：具有回饋的訓練模式能藉由設定動作標準，而提供持續性動作品質的訊息及錯誤動作的糾正訊息，以促進動作復原（古芳菱等，2011）。本團隊在遊戲中融入明確的視覺回饋，像是明顯的計分數字；遊戲畫面會因執行動作的正確性與否而有不同的特效，例如手碰觸到正確寶石時，畫面中的寶石會變大，碰觸錯誤寶石會縮小，讓患者直接看到動作執行的狀態。聽覺回饋的部分採取鼓勵性的詞語，例如「做得好、好棒」。回饋機制採取帶寬回饋: 當患者產生標準動作時才會出現。同時也有遊戲音效，像是鈴聲、掌聲、歡呼聲或是在遊戲失敗時的警示聲等，增加患者在遊戲中的趣味性（翁漢騰等，2012）。虛擬實境的訓練其中一特色，就是可增加練習與重複次數，有研究指出每一次虛擬實境訓練要包含四種手部動作技巧如肌肉力量、移動速度、獨立動作程度及關節活動度，每種技巧要重複做40-60 次，總共 160-200 次動作 (Boian et al., 2002) 或者 250-300 次 (Merians et al., 2006) 。據此，本遊戲執行前由治療師根據患者上肢活動度，選擇合適的遊戲難度，遊戲動作可容許正負五度的角度誤差，盡可能確保患者每次的動作都達到目標的

角度。同時具重複性，單一遊戲之任務可依患者的目標、體力狀態重複執行，次數不限。

（二）、虛擬替身

虛擬替身是將操作者的身體、肢體以虛擬人物的畫面投射於在螢幕上，讓操作者可以專注遊戲中，虛擬替身建構過程可分成三個部分：(1) 外皮模型；(2) 骨骼系統；(3) 外皮與骨骼系統整合。外皮模型為依照人體外觀建構之 3D 幾何模型，骨骼系統包含人體骨頭與關節，而將外皮與骨骼系統整合後，可讓外皮與骨骼系統一起活動，當移動骨骼系統時，會帶動外圍的皮膚。另外，操作肢體的動作與虛擬替身的動作是連動的，能提供清楚的視覺回饋，讓操作者知道自己動作執行的狀況，也能提升操作者與遊戲的互動（劉品如等，2013）。據此，在不同的遊戲情境中設計不同的虛擬替身（圖 1），例如球類遊戲須讓患者能夠看到雙側上肢的動作與球飛行的軌跡，所顯示的是全身的虛擬人物，摸寶石遊戲中，因是單手執行且為第一人稱視角，所以僅顯示手臂的部分。

圖 1
遊戲畫面中的虛擬替身

（三）、難易度

有學者曾探討知覺訓練難度對訓練成效的影響，研究結果顯示情緒激發與知覺訓練難度之交互作用會影響受試者的自我效能與學習動機，因此不同情緒狀態的受試者，在學習不同難度知覺的訓練內容時，會產生不同的態度與動機（蕭佳

珮，2009）。同時，有研究結果指出遊戲的難易度對於遊戲經驗中的挑戰及緊張感有顯著的影響 (Nacke & Lindley, 2008) 。有研究亦指出在虛擬實境下設計三種不同抓放測試的難易度對使用者的操作表現有顯著的影響（辛柏陞，2004）。根據以上的研究結果，不同的難易度可能會影響受試者的訓練績效，因此，我們開發共六種體感遊戲（表 1），內建可調整參數，作為遊戲分級 (grading) 的標準，常用的參數有遊戲進行的速度快慢，例如球體飛行的速度、遊戲中元件（球類、寶石）起始位置的遠近、元件（箱子、寶石）的大小等等，為了便於臨床應用，在開始時便已初設難、中、易三個等級，一般而言，遊戲若選擇難的等級，遊戲中的元件飛行速度較快、元件起始位置離患者較遠、大小較小，以此類推，等級中、易則是在這些參數中調整，治療師可以在遊戲前依患者的程度選擇合適的難度，臨床操作上常會以等級中開始，以利調整。

二、系統與器材

（一）*Kinect*

Kinect 是一種透過鏡頭捕捉人體動作的感測裝置，硬體結構包含有：彩色攝影機 (RGB Camera) 、深度攝影機 (Depth Cameras) 、麥克風陣列 (Microphone Array) ，以及底座馬達 (Motorized Tilt) 等。Kinect 可藉由中間的彩色攝影機來獲得彩色影像，另外透過左邊的紅外線發射器來對物體發射紅外線，再藉由右邊的紅外線 CMOS 攝影機來擷取深度影像，藉由雷射反射過程來判斷受測者位置。Kinect 軟體會再針對受測者身體部份與背景物件作區隔，透過圖像識別系統正確判斷受測者的體態，其中包含受測者可能穿著較為寬鬆的衣服或者會有長髮飄逸的情形，這些差異均能夠被正確解析並識別為正常人體姿態。當受測者的身體部位識別完畢後，Kinect 軟體會將所擷取到的資料整理成一組骨架圖，藉此用於各式的遊戲軟體應用（王維倫、陳淨元，2015）。

表 1
六種遊戲介紹

名稱	遊戲說明	設備	分級	參數
雙手擊球遊戲	患者以雙側肩膀外展的動作，向上連續交替擊球。此遊戲是以虛擬替身的概念，畫面中有一人物，可連動患者的肢體動作，此外，此遊戲亦可以將雙手打開到水平高度，在固定近端的情況下，以手肘彎曲的單關節動作來擊球，做為肩膀穩定度與手肘動作之訓練。	Kinect	難、中、易	球體飛行的速度、起始位置，關卡數的多寡。
宇宙飛船大冒險	患者以坐姿或站姿進行身體的左右重心轉移。患者化身虛擬飛船在太空中前進，畫面中有寶石、隕石隨機出現，碰觸寶石得分，碰觸隕石為失敗，同一關可失敗 10 次。	Kinect	難、中、易	遊戲速度、隕石寶石的數量
伸手摸寶石	患者伸手碰觸寶石，目的為訓練伸手動作及上肢穩定度。患者在宇宙飛船中，畫面出現五顆不同顏色之寶石，平均分布於畫面九點經十二點到三點鐘方向，遊戲為五關，每一關開始時，寶石會隨機閃動，患者必須伸手至寶石的位置停留數秒鐘，此時寶石會逐漸放大後消失，若碰觸錯誤的寶石，寶石也會消失但會產生失敗的音效並且扣除分數，遊戲結果會顯示於最後的統計中。此遊戲也使用虛擬替身之概念，畫面中會有患者的上肢替身，並且與患者動作連動。	Kinect	難、中、易	寶石出現的位置、上肢停留的秒數
時鐘遊戲	患者以坐姿，以雙手模擬時鐘的指針，訓練雙側上肢協調性以及近端穩定度。畫面的時針會呈現紅色半透明狀，患者的上肢在畫面中為實體黑色，須精準擺出畫面中的紅色指針之區域，維持三秒鐘。此遊戲結合上肢 PNF 與跨越中線的概念。	Kinect	無分級	無分級
隔空取物	患者以坐姿執行，患者須將手指張開，手臂懸空於偵測裝置上，當偵測成功時，畫面中會出現患者的手掌、箱子、黑洞，患者用抓握的動作抓起箱子，移動至黑洞的位置，鬆開手指，箱子會掉入黑洞中同時發出成功的音效，接著下個箱子與黑洞會再次出現在不同位置，若中途鬆手或沒有丟入黑洞中則算失敗，表現將於全部完成後顯示。	Leap Motion	難、中、易	次數、黑洞與箱子的起始位置遠近，相隔越遠越困難。
手捏箱子	患者以坐姿，畫面中央有一箱子，患者須將手指張開，手臂懸空於偵測裝置上，患者用指尖抓握的方式捏起箱子並垂直拿起到指定高度，成功會有音效，若中途鬆手或未拿到指定的高度，則有失敗音效，結果將呈現於全部完成後。	Leap Motion	難、中、易	箱子大小，越大越簡單。

（二）*Leap Motion Controller*

Leap Motion Controller 是感測裝置。根據內建的兩個鏡頭從不同角度捕捉的畫面，建立手掌在三度空間的運動訊息，偵測的範圍大概在感測器上方 2.5 公分到 60 公分之間，大致呈現一個倒四棱錐體。Leap Motion Controller 會建立一個直角座標系，藉以偵測手掌、手指、手勢、手持工具等動作訊息（Guna et al., 2014）。Leap Motion Controller 是一種低成本、低複雜性的系統裝置，可用來追蹤手部與手指動作（Weichert et al., 2013），同時具易於操作的特點，使它經常被用於復健的領域。有研究指出 Leap Motion controller 可以用於中風患者早期的手部操作訓練（Gieser et al., 2015）。

（三）*Unity3D*

Unity 3D 是一種遊戲開發引擎，可以支援許多系統或裝置之遊戲開發。這是一個低成本且易於操作的平台，適合中小型的遊戲開發計畫。編輯者可自由且快速地設計、編輯自己喜愛的效果與畫面。Unity3D 主要是透過選取、拖曳的方式建立遊戲，同時平台內也有許多腳本可以被使用，是一個易學方便使用的遊戲開發引擎（Labschütz et al., 2011）。

三、研究問卷

為呈現本系統的使用友善性，由患者在完成課程後填寫 Feedback Efficacy and Systems Evaluation 問卷（Liao et al., 2018）。FEASE 問卷為李克式（Likert scale）問卷，此問卷共 11 題，分為回饋與速度、運動效果、自我效能三大部分，每題總分皆為 5 分，1 分為非常不同意，2 分為不同意，3 分為中立，4 分為同

意，5 分為非常同意。此問卷題目中提及「畫面提供的視覺化提示是非常有用且易懂的」、「使用這個設備後，我對於運動感到更多的動機」、「使用 Kinect 做運動可以讓我的患側手嘗試更多的新任務」等等題目，可調查患者對於使用體感遊戲復健的感受。

四、研究對象

研究對象的納入條件為 (1) 經醫師診斷為中風;(2) 有正常的視、聽覺能力；(3) 認知功能正常，可配合兩步驟以上指令；(4) 布朗斯壯動作分期 (Brunnstrom Stages) 上肢近、遠端均至少為第三期；(5) 能維持靜態坐姿達 15 分鐘以上。考量體感遊戲包含大量聲光刺激，故將癲癇做為本研究之排除條件。若符合以上條件，患者須簽屬自費同意書並完成至少 10 次，每次 60 分鐘之一對一治療。

結果

一、遊戲製作流程

本團隊與國內中央大學資工系合作，分為醫療端與資工端，由醫療端之治療師、醫師提出遊戲腳本並且進行會議討論，確認醫療端的想法與需求，資工端即進行遊戲製作，製作完成後會經過一到二次線上演示，醫療端與資工端交換意見後進行修正。上線服務前需要臨床演示並找患者實際使用，確認無其他問題即可投入服務。

二、患者的人口學資料

本團隊自 2019 年 9 月到 2021 年 1 月共計 30 名中風患者參與，約 380 人次，詳細人口學資料如表 2。參與者中，最年輕 26 歲，最年長 82 歲。缺血性中風 25 人，其中左側大腦梗塞為 12 人，右側大腦梗塞 13 人。出血性中風 5 人，左側大腦出血為 2 人，右側大腦出血為 3 人。全部僅有 4 人曾經在他院接觸過體感遊戲，皆為復健場所之治療活動，以不定時間與頻率的方式，使用市售遊戲結合 wii 設備執行如球類、划船等遊戲。

表 2

人口學資料 (*N*=30)

	Mean ± *SD*	*n*
年齡（歲）	43.4±15.3	
性別（男/女）		17/13
發病時間（月）	8.3±3.2	
出血性/缺血性中風（人）		5/25
左/右大腦中風		14/16
布朗斯壯動作分期		
第三期上肢近端/遠端（人）		3/3
第四期上肢近端/遠端（人）		13/11
第五期上肢近端/遠端（人）		10/13
第六期上肢近端/遠端（人）		4/3
曾經接觸體感遊戲（是/否）（人）		4/26

三、問卷結果

FEASE 問卷填寫結果如表 3，除了全組別的統計外，本研究以 65 歲為界，將 30 名受試者之數據分為高齡組與壯年組，目的為比較高齡患者與青壯年患者對於體感遊戲的觀點是否不同。回饋與速度方面：由題目 1 作答情形，顯示高齡

組可能對於畫面的理解較為困難。題目 2「虛擬替身的速度」的計分，1 分表示速度太慢、2 分=速度慢、3 分＝剛好、4 分＝快、5 分＝太快。壯年組認為所做出的動作與畫面中替身的動作速度是一致的，不會出現兩者有時間差的現象，而高齡組認為虛擬替身的速度較快。運動效果方面：題目 3 與題目 4 中，兩組患者分數相近，表示認同使用此設備執行復健運動可以帶來更多的挑戰性，且相信手臂功能可得以改善。自我效能部分，兩組在題目 5 有差異，表示壯年組患者較容易藉由此設備促進運動的動機。兩組於題目 6 分數皆為 3.4 分，表示兩組對於遊戲運動沒有特別的偏好，可能是遊戲中的動作與患者平時的復健動作雷同。自我效能部分：題目 7 顯示高齡組的患者對於患側手的狀態較為滿意。題目 8 中，兩組分數皆接近 4 分，顯示兩組都保持正向的看法。綜合題目 9、題目 10、題目 11 可以發現，使用體感遊戲對壯年組患者而言，可以帶來更多信心與自我效能。

表 3

FEASE 問卷

問卷題目	全組別 (*N*=30)	高齡組 (*n*=8)	壯年組 (*n*=22)
回饋與速度			
1. 畫面提供的視覺化提示是非常有用且易懂的	4.3±0.51	3.1±0.32	4.7±0.21
2. 虛擬替身在畫面中的速度	3.3±0.41	4.2±0.54	2.9±0.12
運動效果			
3. 這些運動是很有挑戰性的	4.2±0.58	4.1±0.39	4.2±0.43
4. 我相信我可以透過這些運動來改善我的手臂功能	4.7±0.17	4.5±0.46	4.8±0.15
5. 使用這個設備後，我對於運動感到更多的動機.	4.3±0.31	3.5±0.51	4.6±0.21
6. 我喜歡這些運動勝過我平時在家做的手臂運動	3.4±0.87	3.1±0.55	3.5±1.14
自我效能			
7. 此時此刻，我對於我患側手的狀態感到滿意	3.2±0.71	3.8±0.21	3.0±1.36
8. 我認為患側手的功能是可被改善的	4.1±0.33	3.9±0.51	4.2±0.11
9. 練習這些運動可促進我在日常生活中運用我的患側手	4.5±0.24	4.0±0.35	4.7±0.13
10. 使用 Kinect 做運動可以幫助我變得更獨立	4.4±0.32	3.9±0.22	4.6±0.31
11. 使用 Kinect 做運動可讓我的患側手嘗試更多的新任務	4.4±0.43	4.2±0.22	4.5±0.31

討論

本研究紀錄開發遊戲並實際運用於中風患者之復健治療的過程，以下將針對實務經驗與相關議題進行討論。

一、患者年齡會影響使用意願與活動理解

在人口學資料中可以發現，使用者平均年齡約為 43 歲，在中風患者的族群中是較為年輕的，過去普遍認為此類型的復健模式多是給兒童，如：發展遲緩、腦性麻痺，因電玩可以吸引兒童的興趣，增加動機與治療的多樣性，能夠促進良好的上肢動作訓練成效（翁漢騰等，2012；Luna-Oliva et al., 2013）。然而，在中風患者身上也可以看到相同的益處，惟較高齡的患者，對於體感遊戲或者虛擬實境的接受度較不佳，在其他研究中也有相似的紀錄，所以體感遊戲必須導向人性化操作，更直覺性、簡單、易學和有效的運動模式（許晉榮、林朝清，2020）。

本團隊在收案時並沒有篩選年紀，只要適合的對象皆會詢問意願，但願意接受此治療模式者，多為三十到五十歲左右的患者，在本團隊的服務經驗中，有三名八十歲以上、五名七十歲以上認知功能正常之年長患者，但在示範過程中，治療師發現年長患者無法快速理解畫面中所呈現的動作與意義，需要多次的講解與示範，同時，從 FEASE 問卷中發現，高齡組可能較不易理解遊戲畫面與提示。為此，我們在每個遊戲第一次執行前，都會撥放遊戲過程的影片，患者對整體的流程會比較有概念。在高齡組的患者中，參與體感遊戲的動機較壯年組低，同時，對於使用體感遊戲所帶來的益處與促進的自我效能感在高齡組患者是較弱的，因此，治療師的引導十分重要，在必要時會在遊戲前有肢體的引導。然而，當年長患者能夠理解活動執行的方式後，其實並不影響整體的使用。有研究指出他們利

用 Kinect 為基礎的虛擬遊戲讓高齡老人得以增加社交互動與運動時間，結果分析認為年齡與學歷並不影響高齡者使用虛擬遊戲，並且活動帶領者是非常重要的角色，若沒有良好的活動帶領，患者使用的狀態與意願將會降低(劉品如等，2013)。

二、使用非市售遊戲作為治療媒介的優缺點

曾有針對參與復健用體感遊戲的中風患者的調查指出，患者需要或期待有治療師設計的遊戲 (Liao et al., 2018) 。由於市售遊戲多是針對沒有疾病的族群，遊戲難度普遍較高，並且無法有效的分級（翁漢騰等，2012）此外，市售遊戲強調整體的動作表現，例如球類、競技、舞蹈遊戲，較少獨立區分出單一部位訓練的項目，使得市售遊戲的難度與患者的能力落差過大而無法調整；或是需要太多綜合性能力，無法專注於訓練某個部位。

非市售遊戲在設計時即可有明確的訓練目標，使用時也可依據患者的情況設定不同的參數。遊戲的分級也常以模板化的方式執行，例如易、中、難三種模板，治療師只需在遊戲前選擇即可。若有良好的後台管理系統，更細微的調整也是可行的，例如本團隊在新開發的系統中加入了可以調整關節角度、維持秒數的設定（圖 2），讓治療師在參數設定上可以更為個別化。雖然非市售遊戲有許多訓練上的好處，但仍然有缺點，像是遊戲的產出需要時間與耗費人力，遊戲較為陽春，細膩度與娛樂性不及市售遊戲，可能無法使患者維持興趣與持續運動的動力（陳虔慧等，2015）。

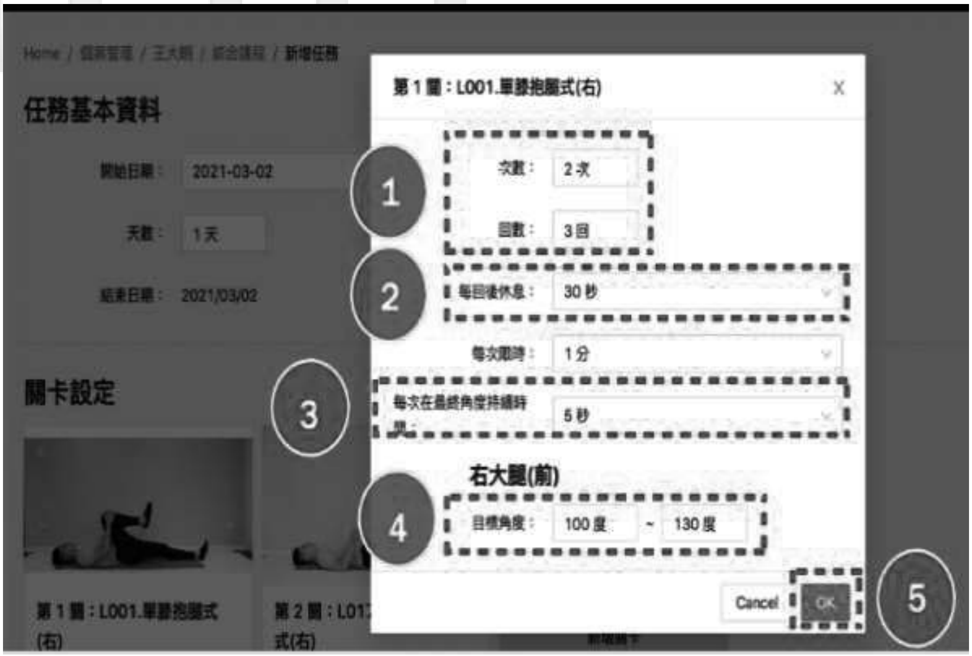

圖 2

可調整角度、秒數之後台管理系統

三、體感遊戲無法直接提供給布朗斯壯動作分期較低的患者

體感遊戲強調人機互動，中風患者在布朗斯壯動作分期較低時無自主動作，難以獨立進行遊戲。在本團隊的經驗中，患者上肢近、遠端多屬於布朗斯壯動作分期第四期以上，少數幾位為第三期。許多體感遊戲之研究的收案條件，近、遠端第三期是最低的門檻 (Afsar et al., 2018) ，也有研究指出上肢近端第五期是最理想的偵測階段 (Cao et al., 2019) 。經驗上，遊戲適用的布朗斯壯動作分期與其設計較有關係，此類型遊戲在設計時，常會將現實中的動作撰寫成腳本製作，例如網球、高爾夫球等等（郭癸賓等，2013），當遊戲設計的目標為達到完整動作角度時，布朗斯壯動作分期較低的患者將難以參與。若在開發新遊戲時，以布朗

斯壯動作分期第三期的動作型態為腳本加以設計，患者將有機會可以使用。但對於第一或二期的患者而言，沒有明顯自主動作且遊戲過程中較難透過治療師直接的肢體引導。因此，搭配機器輔助設備 (robot-assisted device) 對於中、重度的肢體功能損傷之患者較為適合（李承昱等，2018）。本團隊也會針對上肢處於軟癱或是僅有微弱動作的患者，給予機器手臂配合電腦遊戲的治療方式促進動作誘發的效果。

Leap Motion Controller 用於精細動作訓練，上肢遠端動作分期至少要為第三期，過度微小的手指角度難以被所偵測到，若是患者近端動作不佳，而遠端有訓練潛力時，使用治療室中常見的吊帶 (sling) 或者治療師扶持於手肘處，是可行且不影響其偵測的做法。

四、治療師的系統使用經驗

由於體感遊戲需偵測人體的骨架或節點，因此在場地、動作設置上會有一定的限制，像是需要避免障礙物。若偵測範圍中有過多的障礙或是人體，將可能影響偵測的準確性。若使用 Kinect 時，椅子、輪椅、助行器可能會影響偵測 (Mousavi & Khademi, 2014) 。經驗上輪椅的扶手、助行器的橫桿偶會被系統偵測，但遊戲是依據肢體動態的角度變化而驅動，所以此類型障礙物不一定會影響遊戲進行，反而較常會在初始捕捉骨架定位時產生異常，此時，建議患者坐立時，不要倚靠椅背或者向前坐一點；而助行器使用者則可以先拿開助行器，讓系統定位完成後，再將助行器擺回，這樣可以減少異常情況的發生。

Leap Motion Controller 因為偵測角度是朝向天花板，此方向較無干擾的障礙物。此外，動作的角度與患者執行的姿勢也可能會有限制，以 Kinect 為例，接近地面的動作或是以側面、背側面對鏡頭時會造成系統的誤判，這與節點被遮蔽而

無法被辨識有關（劉松庭，2015）。因此，本研究建議使用 Kinect 訓練時，以站姿或坐姿，正面對著鏡頭，上半身與上肢的遊戲較為合適，而 Leap Motion Controller 的偵測範圍是在偵測器上方倒四角體的維度，高度 2.5-60 公分、寬度 50-60 公分的範圍。若超出該範圍，例如手部置於過度側邊、過高或低，皆會造成偵測困難，使用 Leap Motion Controller 訓練時則以坐姿並將偵測器放置於患者前方的桌面上為宜。

光源的部分，由於感測器之骨架偵測是以紅外線技術建立出深度影像以辨識骨架。然而，太陽光包含可見光、紅外線、紫外線三大主要成分，因此會很容易影響影像感測器之判斷，可能導致骨架辨識不準確，治療場地若設置於窗邊且太陽可照射到室內時，可能就會受到太陽光的干擾，當發現有偵測不良的情況時，可以先嘗試屏蔽光線，排除太陽的影響。而室內燈光則不影響偵測。

五、結合日常生活功能情境的遊戲

本團隊首度研發的六種遊戲中皆以動作訓練為主軸，場景設定並沒有特別強調結合真實的情景。體感遊戲若以日常生活功能為焦點的訓練任務對患者更具意義且相關，能夠彰顯職能治療以有意義的活動作為治療主體的觀點，同時也更能有效改善中風患者的上肢功能 (Adams et al., 2017) 。有研究以 Kinect 體感遊戲結合洗澡、刷牙任務遊戲促進個案的盥洗能力，發現個案的盥洗表現、動機、自信心皆有明顯的提升（高嘉駿，2016；涂嘉俊，2019）。由於以日常生活任務為導向的體感遊戲對於增加患者的動作表現以及提升功能有良好的效果 (Laver et al., 2011) ，所以本團隊在下一代即將推出的遊戲中也加入了日常生活任務的情境以及任務，例如在客廳場景中擦玻璃、在廚房桌面上放置茶杯等等（圖 3），期待透過貼近患者的真實生活任務，可以提升患者的動作品質與日常生活功能。

圖 3
結合日常生活情境的遊戲：端茶杯活動

六、跨專業開發遊戲經驗

本團隊所使用的遊戲開發平台為 Unity3D，此平台的使用需具備基本的程式語言編寫的能力，本團隊尋找中央大學資訊工程學系共同合作開發。由於養成背景不同，醫療端與資訊工程端需要溝通才能順利開發，治療師可以先設計腳本，腳本中呈現目標動作以及主要的任務、畫面場景、擺設、色調。此外，依據病人訓練記錄調整遊戲場景參數，增加挑戰性來讓病人維持使用的動機（裴駿等，2013），遊戲分級的參數也是重點，比較常見的像是次數多寡、遊戲的速度快慢、畫面中物體位移的遠近、遊戲時間的長短等等，都可以量化的方式分級後記錄在

腳本中。如果能在遊戲中加入競賽的元素，有時可以增加遊戲的難度與挑戰性，更能夠促進參與的動機。

另外，加入會導致失敗的元素也是很好的方式，可與活動分級連結，像是以煮飯遊戲為例，若動作完成的速度較慢，鍋上的食物就會燒焦，以此鼓勵患者能夠加快動作的執行速度，遊戲的難度則可用食物會開始燒焦的時間加以分級。腳本的形式建議以圖像化或是影片的方式，配合文字說明會比較容易理解，非復健領域的人員不易理解動作的專有名詞或者不清楚此動作角度該如何計算，圖像化是較為清楚的方法。另外，治療師所設計的動作與任務，製作成遊戲後不一定能夠順利被感測器偵測，所以完整的腳本可以讓資訊工程人員先判斷該動作是否會有執行上的困難。

七、未來議題之探討

本研究為開發非市售體感遊戲與使用的經驗，目前多運用於中風患者，不僅是動作層面還有認知功能或日常生活功能的研究方向。體感遊戲可運用的範圍很大，像是失智症、癌症、骨科疾患，不過現在多數還是停留在研究階段，臨床實務的紀錄較少，未來若持續開發系統，可將其他診斷納入，增加運用的廣度。雖然 Kinect 逐漸淡出體感遊戲的市場，但對復健領域而言，其低成本、易操作的特性，配合適切的遊戲，仍是良好的訓練媒介。另外，本系統在服務架構上屬於自費治療，在臨床上較為少見，未來也可以調查患者使用此療程的感受、意願與相關資訊，加以分析後可做為其他職能治療單位開發體感遊戲自費治療的參考。

結論

本研究為介紹應運非市售體感遊戲於中風患者的經驗，從自行遊戲開發、患者體驗以及治療師實務使用的心得。Kinect 與 Leap Motion Controller 不論在研究方面或臨床觀察上都是有臨床運用價值的，非市售遊戲的開發與使用也讓體感遊戲更符合治療的需求，希望透過本研究的介紹，帶給職能治療師相關的資訊，自行開發或與他人合作都是適切可行的方案。

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Original article

Development and Application of Non-Commercial Somatosensory Games in Rehabilitation for Patients With Stroke: Using Kinect and Leap Motion Controller Devices

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Abstract

In recent years, virtual reality and somatosensory games are widely applied in stroke rehabilitation. In this study, we developed non-commercial somatosensory games using Kinect and Leap Motion Controller devices and examined the experience of patients with stroke on playing these games. We reported features that should be noted when developing the games, such as the avatar, visual-auditory feedback, and grading concepts. We also explored the user friendliness of the device. A total of 30 patients with stroke were recruited (mean age: 43.4 years old, onset time: 8.3 months). 25 patients were ischemic stroke, and 5 were hemorrhage stroke. We developed six non-commercial games by Unity 3D, and combined ball activities and science fiction in these games. The primary goal of these games was to enhance motor function of the proximal and distal parts of the upper extremity. All patients received the therapy for 60 minutes/session, two sessions/week, for at least 10 sessions. In each session, the therapist would let the patient play four games appropriate for his/her ability level, with each game lasting for 15 minutes. All participants filled out the Feedback Efficacy and System Evaluation Questionnaire after they finished 10 sessions. The results showed that most patients had positive experience with the treatment. Non-commercial games may fulfill the therapeutic needs. We also discussed the possible role of age and environment in clinical applications of the system. This study provides valuable experience on the professional cooperation between therapists and the engineering team. We hope to deliver more information for occupational therapists and make these treatments widely acceptable to patients with stroke.

Keywords: *Kinect, Leap Motion Controller, Somatosensory Games, Stroke Rehabilitation, Virtual Reality*

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