出國報告（出國類別：開會）

參加2024年第22屆國際人因工程研討會

服務機關：勞動部勞動及職業安全衛生研究所
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派赴國家/地區：韓國濟州市
出國期間：113.8.25-8.30
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摘要

本次行程主要為參加「2024年第22屆國際人因工程研討會」，由陳志勇研究員兼組長及劉立文研究員兼組長等2人前往韓國濟州市參加，並發表本所研究成果「Investigation on Workload and Muscle Injuries of Care Service Personnel under Different Shift Systems」、「Investigation of the Use of Work Assistive Devices by Caregivers in Long-term Care Facilities」、「The Investigation of Workload and Use of Different Assistive Devices for Nursing Assistants」、「Lower Back Loading Estimation Based on Dynamic Images of Workers Performing Manual Lifting」等4篇論文。論文內容分別為本所對於照顧服務員工作內容及工作負荷進行的調查及分析，並提出降低工作負荷之建議；以及應用影像辨識技術，結合電腦輔助運算，協助事業單位在進行人工物料搬運作業中，對於工作者下背傷病風險評估及預防管理。

本次大會於8月25日至29日期間辦理為期5天，大會主題為「Better Life Ergonomics for Future Humans“未來更美好的生活人體工學”」，旨在探討應用人體工學增強生活福祉方面的作用，以及在數位革命時代的演變，及其對人類未來的潛在影響。會議期間共計有超過來自全世界各個地區超過1720位、分別來自歐洲、北美洲、南美洲、亞洲等地的51個以上國家或地區的專家學者，參加本次的盛會；會中來自全世界的專家學者在會議議程中，發表了超過1150篇以上的論文演講，還舉辦由7場主題演講(keynote speech)，另外還舉辦了70多場的平台論壇、工作坊會議、國際標準ISO技術會議及重要議題座談會等等，各項議題跨越過去、現在到未來，非常的豐富而多元。國際人因工程學會IEA是各國人因工程學會所組成的機構，IEA每三年在世界各地辦一次國際研討會，也是國際人因工程學界最主要的會議。我國清華大學工業工程系王明揚教授也曾經擔任過IEA的理事長，本次研討會我國也有王明揚教授、紀佳芬教授、林久翔教授、石裕川教授、林瑞豐教授、張堅琦教授等等超過10個以上大學的50餘名教授學生參加本次會議。

就整體而言，肌肉骨骼傷病、安全、健康、使用者介面、工作分析與設計、虛擬實境/擴增實境/元宇宙、運輸人因工程、人工智慧AI等是發表數最多的主要研究論文議題，而肌肉骨骼傷病研究相關議題則是發表論文篇數最多的議題，這些研究議題影響層面涵括了一般使用者與職場工作者，從工作與生活、從現在到未來、從人因生理到社會心理等各個層面，對於本所未來的研究方向規劃，極具有參考價值。

關鍵字：國際研討會、肌肉骨骼傷病、人因工程

目 錄

壹、 目的

本次行程主要為參加「2024年第22屆國際人因工程研討會」，研討會於8月25日至29日在韓國濟州市舉辦。會議期間由陳志勇研究員兼組長及劉立文研究員兼組長等2人前往並發表本所研究成果「Investigation on Workload and Muscle Injuries of Care Service Personnel under Different Shift Systems」(照顧服務人員使用不同移位工具的工作負荷及肌肉骨骼傷害調查)、「Investigation of the Use of Work Assistive Devices by Caregivers in Long-term Care Facilities」(長照機構對受照顧者使用工作輔具調查)、「The Investigation of Workload and Use of Different Assistive Devices for Nursing Assistants」(照顧服務員工作及使用不同工作輔具調查)、「Lower Back Loading Estimation Based on Dynamic Images of Workers Performing Manual Lifting」(基於勞工進行人工物料搬運時動態影像的下背負荷分析)等4篇論文，研究內容主要係本所對於照顧服務員工作內容及工作負荷進行的調查及分析，並提出降低工作負荷之建議；以及應用影像辨識技術，結合電腦輔助運算，協助事業單位在進行人工物料搬運作業時及作業後，以協助事業單位對於工作者下背傷病實施風險評估及預防管理。經由國際性活動的參與，透過論文的發表，可以讓世界各國人因工程領域相關研究人員瞭解到台灣之研究能量與水準，除可收集各國在人因工程領域主要的研究議題外，亦可增加本所在國際上的能見度，讓更多世界各國人因工程領域研究人員，了解台灣在人因工程領域上的研究成果。

貳、 參加會議過程

國際人因工程學會(International Ergonomics Association,IEA)是各國人因工程學會所組成的機構，也是國際上對於人因工程研究最有影響力的組織，我國以中華民國人因工程學會的名稱加入，並且參與 IEA 技術委員會的研究工作，致力於國際合作與交流。

IEA 每三年在世界各地辦一次國際研討會，這也是國際人因工程學界最主要的研討會議，每一次依其主辦單位與召集人不同，在全世界各不同國家舉辦。本次大會是由韓國人因工程學會(The Ergonomic Society of Korea ,ESK)主辦。本次研討會期間國際人因工程學會也選出新任的理事長，由南非金山大學教授 Prof. Andrew Thatcher 擔任，新任的理事長與我國人因工程學界(如圖1)，有相當友好的關係，我們也藉著會議空檔當面邀請 Andrew Thatcher 理事長有機會來台進行學術交流。

本屆2024IEA 會議的理監事及辦理大會的各國人因學會理事長和聯絡人(黃色箭頭為前任人因學會理事長 Prof. Dr. José Orlando Gomes，紅色箭頭下方為我國人因學會蘇國瑋理事長，綠色箭頭下方新任的理事長 Prof. Andrew Thatcher)

圖1　本屆2024IEA 會議主辦團隊

IEA 國際研討會提供一個國際交流的平台，推廣與交流在人因工程的一般性理論、非應用與應用領域的研究資訊，包含在工作場所設計、作業設計、人體工學、認知人因工程、社會組織人因工程、健康照護人因工程、滑跌倒危害、使用者分析、兩性工作健康、肌肉骨骼傷病之風險評估與管理、肌肉骨骼傷病案例分析、肌肉骨骼傷病分析技術、運輸人因工程、高齡人因工程設計等領域的資訊，可謂非常全面性，藉此可以獲得全世界在人因工程各分支領域的最新研究現況，這些資訊對於我們現在研究工作的調整及未來的研究規劃有很大的幫助。

本次大會的主題是大會主題為「"Better Life Ergonomics for Future Humans"“未來更好的生活人體工學”」，旨在探討應用人體工學增強生活福祉方面的作用，在數位

革命時代的演變及其對人類未來的潛在影響。將人因工程融入生活與工作中，與落實與實踐，推廣與應用，讓人因工程的概念與設計無處不在，增進人們的生活福祉與工作效率。

本次大會於8月25日至29日止辦理為期5天，會議期間共計有超過來自全世界各個地區超過1720位、分別來自歐洲、北美洲、南美洲、亞洲等地的51個以上國家或地區的專家學者，參加本次的盛會；會中來自全世界的專家學者分別在30個議題類別的225個會議議程中發表了超過1150篇以上的論文演講，還舉辦由20個國際大師的主題演講(keynote speech)，另外還有17 個專業的平台論壇、7個工作坊會議、21 個國際標準 ISO 技術會議、31 個重要議題座談會等等，研究資訊非常的豐富而多元，是人因工程領域在國際上最重要的學術活動會議。我國清華大學工業工程系王明揚教授也曾經擔任過 IEA 的理事長，我國人因工程學界也有清華大學、陽明交通大學、台灣科技大學、成功大學、東海大學、中國醫藥大學、中山醫學大學、台北科技大學、元智大學、朝陽科技大學、醒吾科技大學、高雄科技大學、屏東科技大學等10餘所大學，包含王明揚教授、紀佳芬教授、林久翔教授、石裕川教授、蘇國瑋教授、林瑞豐教授、張堅琦教授、周金枚教授、陳美香教授、李昀儒教授、羅宜文教授、陳慶忠教授、賴學儀教授、許聿靈教授、李育奇教授、黃育信教授等等超過50餘名教授學生參加本次研討會議(圖2)。

圖2　我國參與會議的大學教授

本次國際人因工程研討會每天都有安排1~2場 Keynote 專題演講，提供大會選出近來國際間特別重視的人因工程議題，講題包含 Innovation for A Truly Better Human Experience 、ISO/TC 159 Ergonomics 、 To Hell and Not Back Yet in the Less Known World of

Informal Work 、 Communication between Ergonomics and Related Themes in Standardization 、 Digital Healthcare 2024：Age of Generative AI、Closing the AI Innovation Gap、Smartphone-based Driver Status Monitoring for Safer Driving、Rehabilitation & Ergonomics, SMART SCIENCES、Advancing Musculoskeletal Models for Digital-Age Human and Health Engineering、Stochastic Modelling of Biomechanical Systems、The Way of People-Centric with Love and Care 等等，講題非常的多元。其中，對於" Welcome to ISO/TC 159 Ergonomics"、" Communication between Ergonomics and Related Themes in Standardization"、" Stochastic Modelling of Biomechanical Systems"、" The Way of People-Centric with Love and Care "等國際人因工程標準、人因工程標準化研究、肌肉骨骼健康的數位模型研究、生物力學系統建模、以人為本的人因工程等專題演講，都覺得獲益不少，這些也是剛好目前我們已經納入下一階段規劃的研究主題，也正積極收集相關資料規劃研究中。不過也因此，有許多有興趣的發表、座談、討論或工作坊會議是同一個時間，在不同的會場同時展開，而除了大多數的發表可以在會議資料中找到摘要簡介外，座談、討論或工作坊會議，除了題目以外並沒有書面資料可以參考，難免就必須有所取捨。

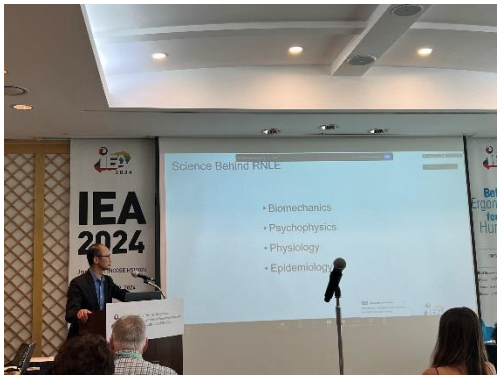
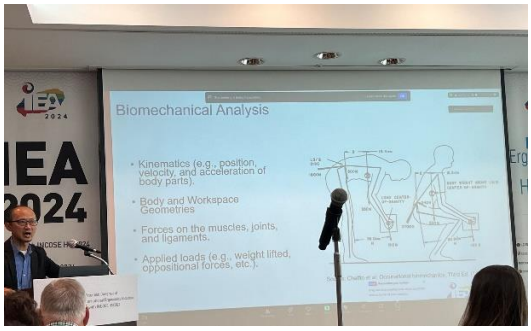
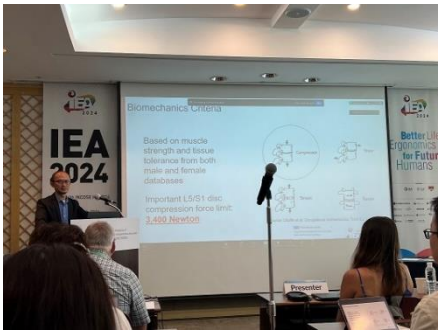
工作中相關的肌肉骨骼傷病問題，一直以來都是我們關切的問題，依據我國民國102年至111年勞工保險現金給付職業病件數統計分析，扣除掉109年因 RCA 事件法院判決之後追溯追加的職業性相關癌症人數及111年 COVID-19大流行期間受感染的生物性危害影響人數，工作相關的手臂肩頸肌肉骨骼疾病及職業性下背痛是職業病給付人次最多的前2位。而國內外勞工因為工作所引起之職業性肌肉骨骼傷病（Work-related Musculoskeletal Disorders, WMSD）儼然已成為勞工最主要之職業病。根據美日歐各國的職災調查統計，工作相關的肌肉骨骼傷病所造成的損失工作天案件數，占所有職業傷害案件數的比例相當高，美國約為32%，日本約為41.2%，歐盟等國平均約為38%，幾乎各國都在30%以上。工作相關的肌肉骨骼傷害所造成的醫療損失，近年來歐盟約為兩仟一百六十億美元；美國約為一仟六百八十億美元。

本次的肌肉骨骼相關的論文約有75篇，是論文數最多的類別之一，其中包含特定作業的肌肉骨骼傷病現況調查、不同暴露群的肌肉骨骼疾病風險研究、應用智慧科技及視覺技術實施風險評估技術研究、肌肉骨骼疾病風險改善技術研究、心理社會對肌肉骨骼疾病的影響、外骨骼的應用與評估等方面的研究等。這些肌肉骨骼相關的論文大致分類如下：

1. 特定作業或特殊族群的肌肉骨骼傷病調查。
2. 肌肉骨骼傷病評估或量測工具的發展與應用。
3. 介入改善技術或工具的影響。
4. 智慧科技或影像辨識技術輔助評估或風險管理。
5. 外骨骼及科技輔具的應用。
6. 心理社會面因素對於肌肉骨骼傷病風險的影響。

而在2024IEA 的第一場工作坊會議，是由美國 NIOSH 主導辦理，以 The Revised NIOSH Lifting Equation (RNLE) and Ergonomics Standards for the Prevention of Musculoskeletal Disorders (MSDs)這個主題，討論應用修正版的抬舉公式及人因工程標準來預防肌肉骨骼傷病。美國 NIOSH 對於1994年針對抬舉作業下背傷病風險評估的抬舉公式，在歷經2021年9月9月發布了修正版的抬舉公式，除了修正前版的印刷錯誤外，並將後續15個研究7000多位受測者的成果加入，提供可用於計算單一和多個人工物料抬舉作業，計算雙手抬舉作業時造成背部受傷的風險，及複合作業下評估腰部傷病的風險，以減少工人腰部受傷的發生率。這場由美國 NIOSH 舉辦的工作坊會議，在3個小時的時間裡，分別從"Introduction of RNLE and measurements for RNLE including an interactive session"、"How to properly use the NLE Calc including an interactive session"、"Recent international ergonomic standards for physical and psychosocial hazards"、"Guidance in implementing ergonomic standards in the US industry"四個部分來分享(圖3)。

分別從研究的科學方法說明 RENL 是經由生物力學、心理物理研究法、生理學及流行病學四個方面的研究結果綜合彙整出來的一個嚴謹的研究成果，收集了受測者作業時的動力學資訊，如速度、加速度、身體及工作場所尺寸、肌肉關節的施(受)力、抬舉物的重量或反作用力等等，探討兩性在肌肉及身體組織(脊椎、椎間盤等)的耐受性，及3400NT 的限制可操作性等。及對操作中如何預防身體(全部或部分)的疲勞、空間配置的影響、搬運的距離、作業排程、工作與休息時間配置、抬舉頻率、身體能量(心肺功能)支出限制等生理學方面的討論。也分享下背傷病風險是一個多重因子影響的疾病，包含身體體能負荷、生理工作特性(現況可能會有生存者效應干擾)、個體化差異等複雜交互作用的結果，必須多方面的考量，及探討 ISO11228-1在抬舉作業的評估應用，提出使用這個方法的一些限制，及未來進一步研究規劃的方向，包含 RNLE 在實際工作場所評估及介入改善的應用性、有沒有其他未考量的因子會增加 RENL 結果(那些已考量的因子可以移除)、個人化差異對於 RENL 評估可使用性的影響、會不會改變目前的脊椎壓力閾值等等。

	
講者 US. NIOSH Dr. Ming-Lun Lu	Robert R. Fox、Menekse Barim、James McGlothlin(左至右)
	
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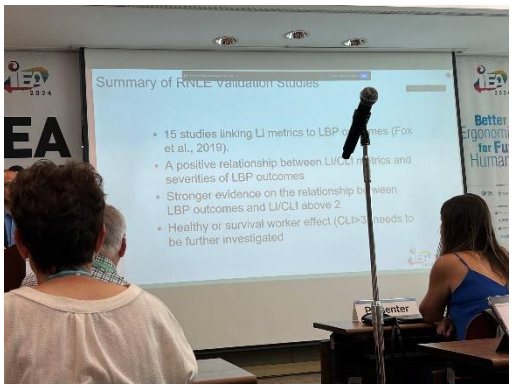	
說明 RENL 的研究過程	人因工程國際標準化

圖3　NIOSH 工作坊會議演講投影片截錄

國際勞工組織之前有出版一本 Ergonomic Checkpoints 還有 app，是一個對於改善安全、健康和工作狀況的簡易實施和執行的方案，有興趣的人可以到 https://www.ilo.org/resource/ergonomic-checkpoints-app 網址去下載，也可以下載 pdf 版。這個 app 有132個 Checkpoints，可以方便評估現場，並有改善建議，是很好的初學教材與現場評估改善的工具(圖4)。ILO 這次有一位專家 Dr. Shengli Niu (Senior Specialist in Occupational Health at the Headquarters of the International Labour Organization (ILO))，做一場專題報告，主要是談論新的職業疾病表列的修訂。這個表列的目的是用來協助職業

疾病診斷與預防，這次主要是介紹其中人因工程有關的肌肉骨骼傷病與心智行為問題。此專題也提到針對特殊族群如青少年、高齡之特殊考慮。以下為部分舊版表列作為參考，新版及其說明我們可以至 ILO 官網購買。

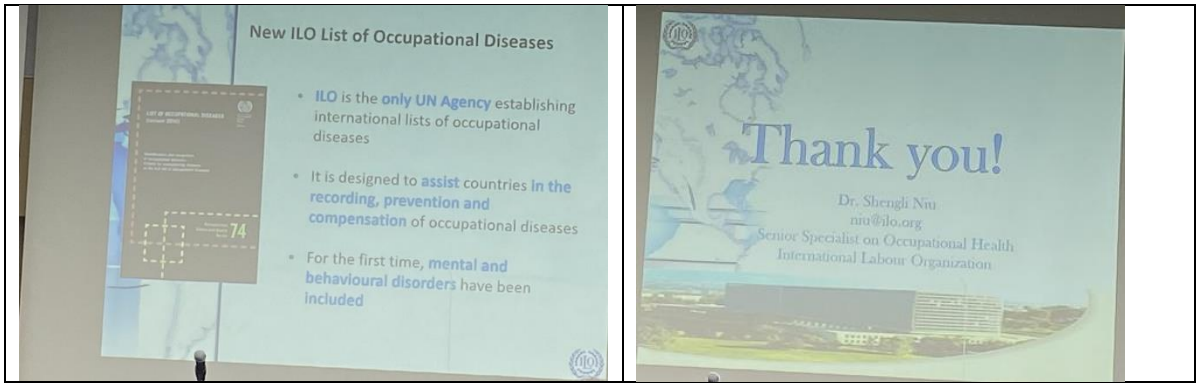

圖4　ILO Dr. Shengli Niu 演講投影片截錄

ILO List of Occupational Diseases

2.3. Musculoskeletal disorders

2.3.1. Radial styloid tenosynovitis due to repetitive movements, forceful exertions and extremepostures of the wrist

2.3.2. Chronic tenosynovitis of hand and wrist due to repetitive movements, forceful exertions and extreme postures of the wrist

2.3.3. Olecranon bursitis due to prolonged pressure of the elbow region

2.3.4. Prepatellar bursitis due to prolonged stay in kneeling position

2.3.5. Epicondylitis due to repetitive forceful work

2.3.6. Meniscus lesions following extended periods of work in a kneeling or squatting position

2.3.7. Carpal tunnel syndrome due to extended periods of repetitive forceful work, work involving vibration, extreme postures of the wrist, or a combination of the three

2.3.8. Other musculoskeletal disorders not mentioned in the preceding items where a direct link

is established scientifi cally, or determined by methods appropriate to national conditions and practice, between the exposure to risk factors arising from work activities and the musculoskeletal disorder(s) contracted by the worker

2.4. Mental and behavioural disorders

2.4.1. Post-traumatic stress disorder

2.4.2. Other mental or behavioural disorders not mentioned in the preceding item where a direct link is established scientifi cally, or determined by methods appropriate to

national conditions and practice, between the exposure to risk factors arising from work activities and the mental and behavioural disorder(s) contracted by the worker

國際標準組織 ISO 這次有幾個場次討論關於人因工程有關的標準。例如 ISO TC159/SC4 (chair : Dr. Jonathan Earthy)，SC4主要是有關 Ergonomics of human system interaction(圖5)，自從ICT發展以來人機介面如顯示器、控制器這些介面設計的人因考慮就很重要，以至於從系統的角度來設計都是現代科技發展的重要部分。當我們談論桌上型、平板以至於手機，顯示畫面變得更小更受限制，但是使用者對於效率的要求卻更高，所以人因設計就扮演關鍵的角色。產品是世界流通的，如果有一個國際標準系統做為參考，那麼系統與系統之間的設計就會更有效率。

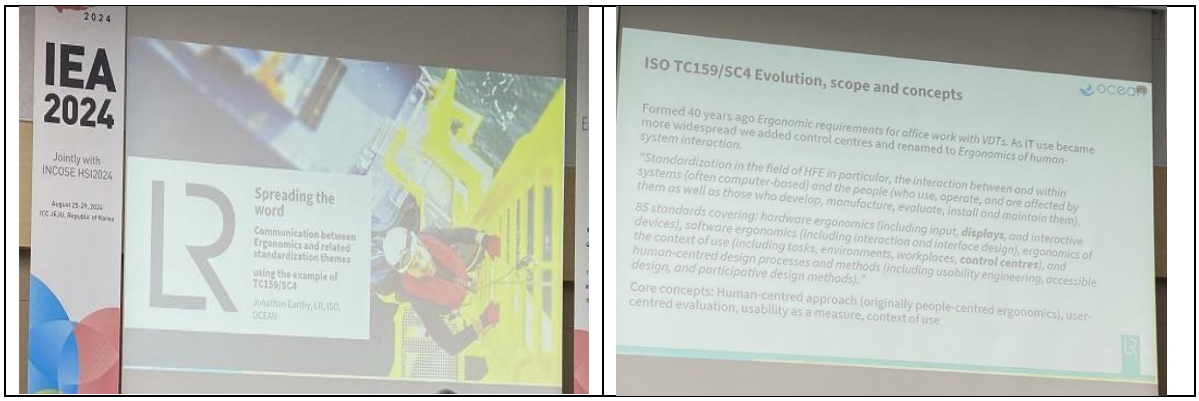

圖5 Dr. Jonathan Earthy 介紹ISO TC159/SC4

Jochen Eckardt (chair of European and international ergonomics standardization committees) 談論 ISO TC159)(圖6-8)；Christoph Preusse 目前主要是參與 ISO/TC 199 ，2008 to 2018年則是 ISO TC 199 and CEN/TC 114 的主席，另外也參與 ISO/TMB Smart Manufacturing Coordination Committee (SMCC)。演講後也有聽眾問到 ISO 標準似乎都很貴，我也是這樣想，或許資訊是需要成本的，因此每個標準依據內容頁數不同價錢不同。

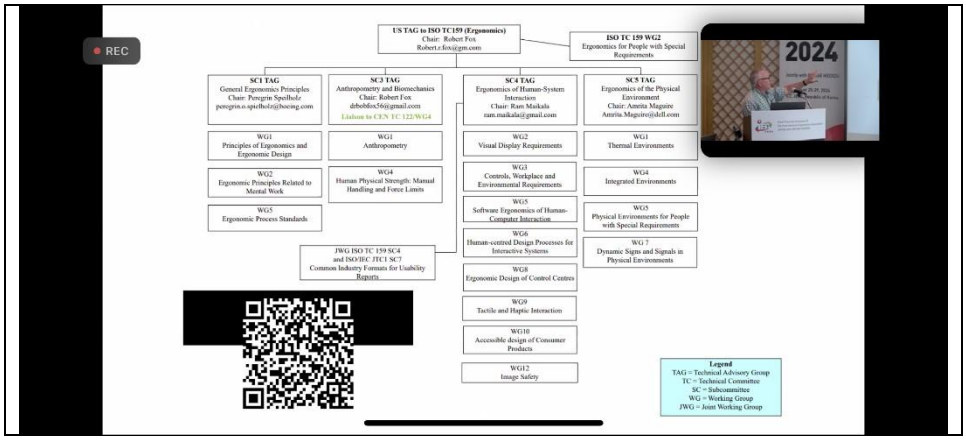

圖6 ISO/TC 159 的架構圖

<table>
<tr><td> 
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<tr><td>德國Jochen Eckardt的Keynote 演講</td><td>德國Christoph Preusse的Keynote 演講</td></tr>
<tr><td> 
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<tr><td>ISO/TC159 的範圍</td><td>機器安全的人因工程</td></tr>
</table>

圖7 Welcome to ISO/TC 159 Ergonomics的Keynote 演講

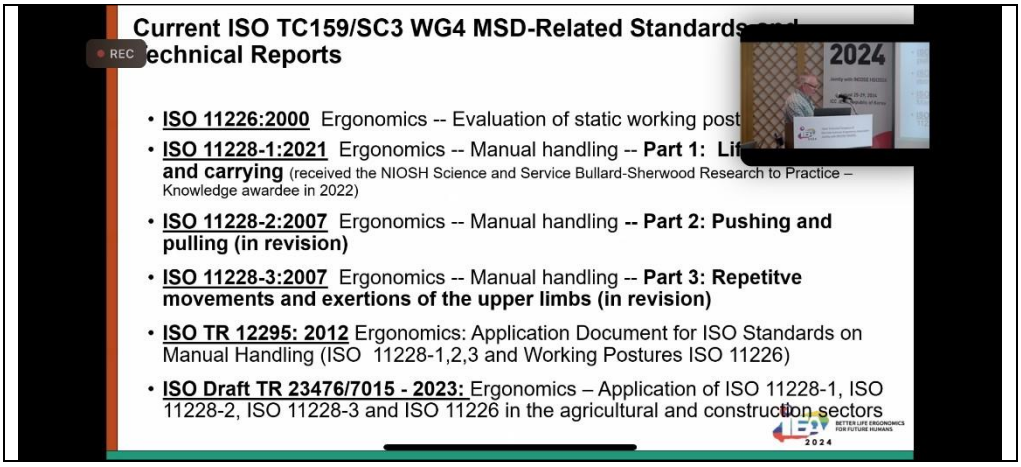


圖8 ISO/TC 159 SC3中的有關WMSD的內容

ISO TC159/SC4介紹外，另外有一場由 Rammohan V Maikala 博士主持的會議，討論 ISO/TC 199技術委員會的工作(Technical Committee 159's work on ergonomics)，特別是在 SC3中有關人體計測與生物力學(人體力學) ，包括 ISO11228 人工搬運。人工搬運在 ISO 標準中分成很多的部分在討論(圖9)，例如：

ISO 11226 : 2000 有關靜態姿勢的評估；

ISO 11228-1:2021是人工搬運的第一個部分，有關lifting、lowering以及carrying；

ISO 11228-2:2007是人工搬運的第二個部分，有關推、拉作業；

ISO 11228-3:2007是人工搬運的第三個部分，有關上肢重複性動作與施力的部分；另外有技術文件的標準。

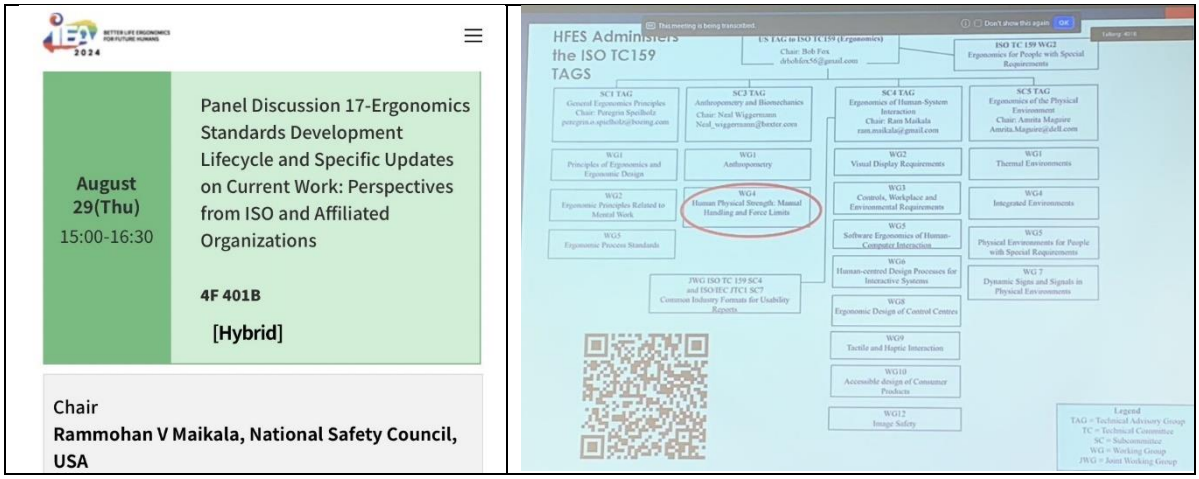


圖9　ISO TC159 中SC3的WG4負責有關人工搬運的討論

ISO 11228-2 目前正在修訂中(圖10-11)，原來的版本是根據兩種方法，

1. 是依據Nicholson-Ayoub push/pull tables中，女性 90% 可以接受的範圍(for 90% female accommodation)。
2. 依據Karlheinz Schaub 發展出來的生物力學模式，然而此一模式很少被使用。

本次修訂保留方法 1 中 Mital、Nicholson 以及 Ayoub 的資料，以及上述方法 2 中有關 strength、compressive and shear forces。另外會增加耐力有關的資料(exposure duration limits)。

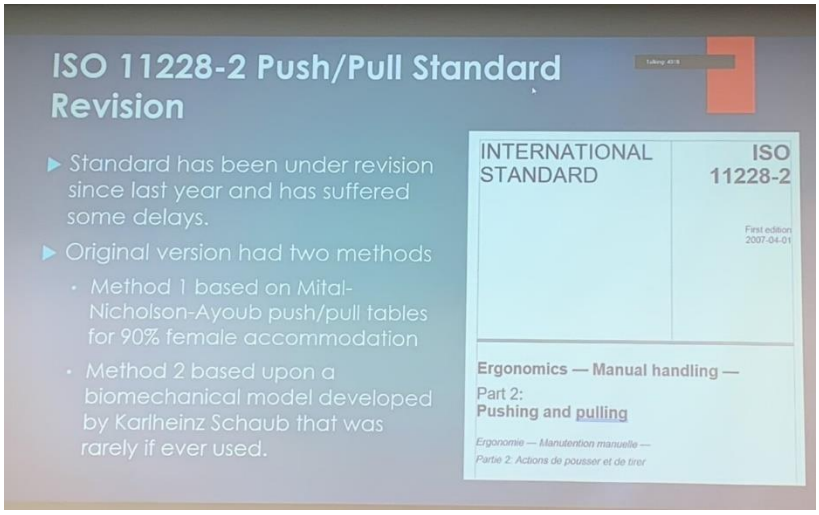


圖10　ISO 11228- 2中使用到的方法

ISO 11228-3 目前也是正修訂中。修訂的主要著重在標準內所用到的方法或工具的含括與驗證原則 (basic inclusion and validity criteria for each of the included tools/methods)。

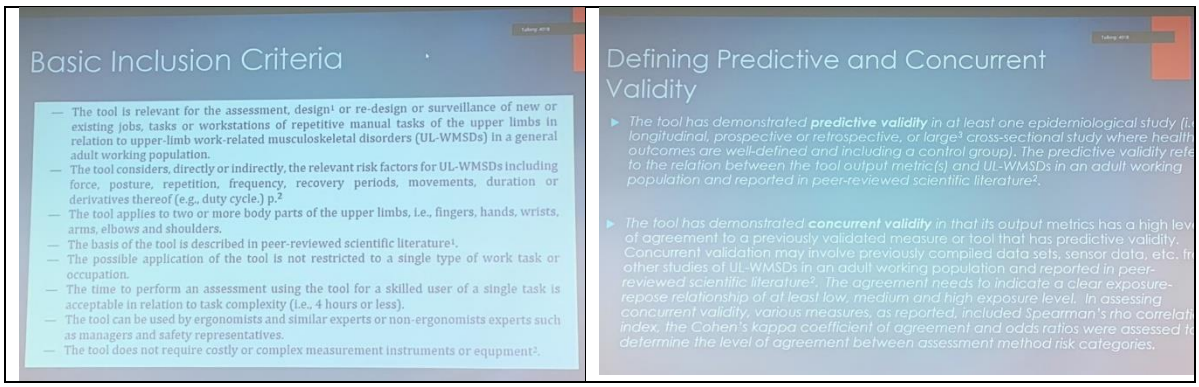


圖11 ISO 11228-3 修訂重點

美國 ASTM 也參與了此次2024IEA 會議並且舉辦了討論會，會議主要在討論外骨骼(exoskeletons) 與 輔助衣(exosuits)(圖12-13)。外骨骼是一種輔助設備，一般具有動力設備，可以幫助肌力較弱的族群，進行日常生活的活動。現在的應用已經著重在生產線上重複性動作，例如上肢外骨骼，可以輔助上肢長時間上舉用力的組裝工作。軍事上也有開發相關產品，協助重體力的裝備攜帶。如果是搬運輔助設備，就需要有下肢外骨骼，算是一種全身性的裝備，如此才會減少腰部負擔。

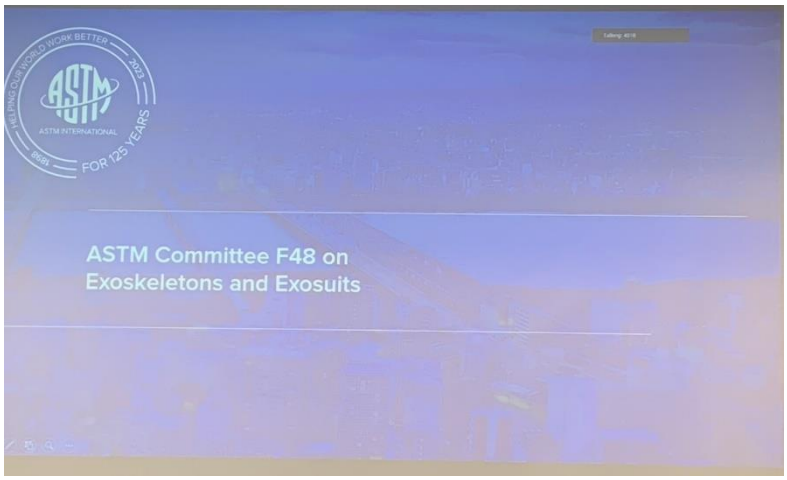


圖12 ASTM F48委員會會中討論外骨骼的標準

外骨骼的標準需要考慮整個產品的生命週期，從設計、製造、使用到廢棄(design, manufacture, usage and disposal)。從不同的角度檢視此一問題，不只是安全、品質與效率，也要考慮諸如人因工程、風險評估等。因此，就會發展出相當多的標準，目前已有23個部分，包括使用者使用訓練、外骨骼的標示與資訊、風險評估(針對在特殊工作環境使用) ，甚至是使用時因步履不穩導致跌倒的風險評估等等。F48人因工程有關的任務編組，目前有6個部分，包括安全、數位人體模型、人體工學、認知、design for population accommodation 與訓練等部分。

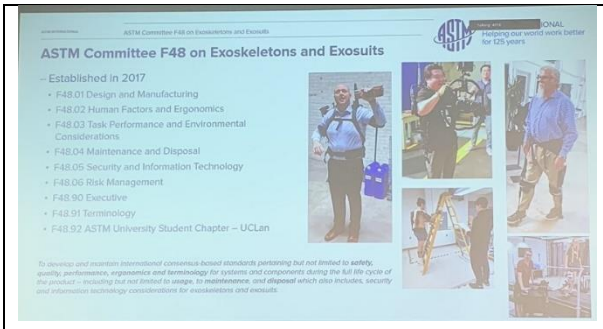
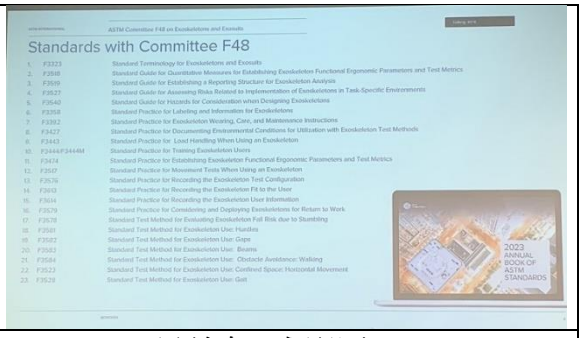
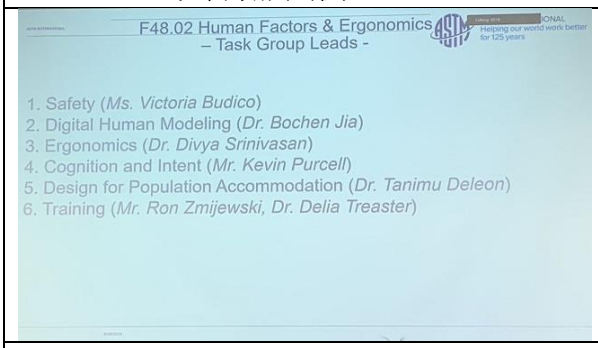
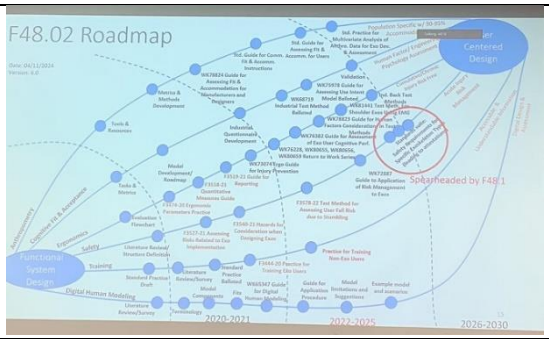
	
ASTM F48的外骨骼圖例	ASTM F48目前有23個部分
	
ASTM F48.02中人因工程任務編組	F48 的roadmap

圖13　ASTM F48的介紹

在大會期間，除了每天都有安排專題演講外，然後接著安排各個不同的論文發表、座談會、技術委員會、平台論壇、海報論文發表等論文發表會議(Session)，直到下午6點以後截止一天的會議，但是很多的 TC 技術委員會則安排在晚間舉辦。各個發表場次並區分為不同的論文主題，分別在十多個會議室同步辦理論文發表。每場會議的論文發表都會依照其主題分類約有4-6篇的論文報告，每一篇進行15分鐘口頭報告跟討論。每一位參加者，可以依照其興趣與需要，選擇不同的論文發表會議與主題參與，因此常常會有跑場的情形。同時在海報論文展示廳也有數百篇不同海報論文發表，大廳有書籍、手冊與儀器設備展覽。因此，本次的大會規模不論就舉辦的場地規模、論文發表的數量與參與的專家、學者、學生非常多，場面相當的盛大熱鬧。所有的發表在濟州市國際會議中心的整個6層樓建築物場地內16個會議室及3個大型展示廳同時展開。雖然大會並沒有公布實際參與的人數，但是從參與論文發表各場次觀察與大會資料來看，共計有超過來自全世界各個地區超過1720位、分別來自歐洲、北美洲、南美洲、亞洲等地的51個以上國家或地區的專家學者，參加本次的盛會，研討會會場如圖

14-16所示。

濟州國際會議中心

研討會開幕式參與人員大合照

圖14 研討會會場

圖15 研討會展覽會場及交流區

圖16 研討會海報論文會場

另外，在安全、健康、使用者介面、虛擬實境/擴增實境、運輸人因工程、人工智慧等議題方面，都是發表數較多的研究論文議題，不過議題領域廣泛，就會顯得有點包羅萬象，深及各個層面，包含相關從業人員及一般民眾的不同危害情境調查、評估技術、改善策略與工具開發、改善策略與工具的實施成效等的研究及探討，也有對於未來世界發展的一些探討，像是人工智慧如何應用於工作與生活，介面的設計及體驗評估等；擴增實境與虛擬實境技術，在工作與生活中的應用與評估，以及發展增加其模擬體感效果的技術與工具；機器人的人機協作探討及應用，工業5.0時代人性化自動化及其適用性，及人因工程面思考的策略等。至於較為傳統但是一直以來的滑跌倒、高齡議題等，也仍然有相當的論文發表篇數的討論，普遍來說，各項研究都加強利用科技技術的介入，以提升偵測、評估、預防、改善及績效等。

參、　心得及建議

就本次參與國際研討會議的心得，發現隨著國際社會的發展與科技的進步，在眾多研究議題中，肌肉骨骼傷病相關的研究仍然是一個非常被高度重視的議題，且與職場相關的研究仍然占大多數。不論是有關肌肉骨骼傷病的現況調查、輔具的應用、科技的導入改善、工作場所設計、作業設計、評估方法、工作的體能需求、個案分析、風險評估管理、恢復工作等等，題目上直接間接掛上ＭＳＤ（Musculoskeletal）的發表論文就高達75篇，其次是關於使用者經驗與設計（UI/UX）的論文也有66篇以上；安全(Safety and Health)相關議題的部分，包含一般大眾及職場的研究有59篇；健康照顧(healthcare)相關議題的部分，包含一般大眾及職場的研究有53篇；有關虛擬實境(Virtual Reality/Augmented Reality/Metaverse) 相關議題的部分的研究約有35篇；運輸安全的人因工程（Transport Ergonomic and Human Factors）相關研究議題則有29篇以上；有關人工智慧(AI) 相關議題的部分的研究約有28篇；有關滑跌倒的相關研究也都有17篇以上；這些是前幾大主題。其他像是高齡人因工程、人體計測實施與應用也分別都有１0篇以上；另外對於工作活動設計、產品設計、永續發展、視覺人因與社會因素等等議題，在本次的大會裡也有較多的論文發表，而這些國際間最新的研究趨勢，可以提供給我們作為未來研究規劃的參考。我們可以關注及發展的議題包括：

(1) 運用智慧新科技簡化評估肌肉骨骼傷病評估技術與風險評估管理，強化人因性危害預防機制。例如應用視覺影像辨識技術輔助人因性危害評估；運用機械深度學習及人工智慧演算，執行工作姿勢評估及風險估算，這個部分正好與本所現在的研究規劃一致，可以借鏡及參考。

(2) 要求合宜的工作設計，整合良好的使用者經驗與設計研究，運用本所過去研究成果，以我國勞工人體計測資料為基礎，導入科技輔具降低工作負荷，以匹配人為中心的幸福工作。例如發展外骨骼技術減輕肢體負重、使用科技輔具減輕工作負荷、良好的工作場所配置及更順手的工具設計。這個部分本所正在規劃，將「合宜的工作設計」規劃為未來主要推動的研究方向，也可能

會導入職安法中有關人因性危害預防計畫的指引裡。

(3) 國內的法令及 CNS 標準，與 ISO/TC159、ASTM 等國際標準間的交互討論，以使國內的相關發展滿足世界潮流趨勢與規範。

(4) 高齡及弱勢勞工在職場的人因工程設計問題等，對於體能較弱族群，為特別的工作負荷考量及排程設計，應用科技輔具輔助經濟生產面的考量。這個部分，還需要更多的調查及新科技新技術的引進，使得評估及介入改善能夠符合實際的需求。

(5) 心理社會問題，所引起的肌肉骨骼疾病或意外高風險。這個議題開始在國際人因的領域裡發展，過去在國際職業衛生研究的領域已經開始受到重視，此次再加入人因工程的考量，應該能更為接近美好的未來生活理想。

(6)

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<tr><td>與美 NIOSH Dr. Lu</td><td>鴻海富士康集團副總裁(IE 中心)陳振國</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>與普渡大學 James D. McGlothlin 榮譽教授</td><td>與德國 BAUA Prof. Thomas Alexander 及 Prof. Klaus Bengler</td></tr>
</table>

圖17　與參與會議的國際學者交流

在大會期間藉由各場次的論文發表會議，也與國內外專家就本所研究交換心得，也和韓國人因工程學會、美國ＮＩＯＳＨ、歐洲 EU-OSHA、德國職業安全衛生研究機構 BUAU 等機構(圖17)及美、日、德、新加坡、香港等國研究人員交換了肌肉骨骼傷病預防、科技人因應用等最新研究的相關議題的建議。分析本次大會所發表的論文，發現其中肌肉骨骼傷病、使用者經驗與設計、健康照護人因工程、安全、虛擬實境、交通運輸人因工程的研究等是論文發表最多的主題。如果以今年大會論文發表的資訊與我國現今的人因工程環境來看，我國關注的事業單位執行人因工程預防工作，用以預防重複性職業肌肉骨骼傷病的做法，與世界潮流趨勢應該是一致的。

參考本次研討會獲得寶貴的資訊，思考本所在人因工程方面規劃未來的研究方向可以有所調整，包含：特定作業的肌肉骨骼傷病調查、人機介面設計、科技人因在肌肉骨骼傷病預防的應用等，且加強與國際人因工程標準及規範與國內相關法規標準的接軌部分，仍要再加強努力。需規劃及探討 ISO TC/159系列的人因工程標準，與產業界的應用，以使國內的經濟活動發展與勞動生產，與國際社會潮流一致。就如本次大會的主題「Better Life Ergonomics for Future Humans」一樣，將人因工程融入與落實在每一個環節，讓人因工程在未來的生活中，無所不在的美好。從工作的作業規劃設計及工作環境的規劃設計階段，就應該要納入人因工程設計的理念，得到最大的成效及最低的投資成本，降低工作負擔，增進勞動與生活的安全與幸福。人因工程創造更美好的未來生活，應該要從源頭開始做起，減少從既有的作業中才去進行人因工程預防，越晚才考量人因工程所要付出的資源與所獲得的成效太不經濟。

其次我國已經快速的邁向高齡化，這些歐美先進國家的高齡化問題及衍生的缺工、健康照護等問題，應該足以讓我國借鏡及學習觀摩，如果能透過人因工程創造更美好的未來生活模式，運用科技提升作業(包含工作與生活)效率，降低工作負荷，減輕肌肉骨骼傷病與人的老化問題，也許缺工問題、經濟生產的困境與社會的活力問題，提升中高齡就業與創造延長高齡就業的條件，透過適當的進行設計規畫，延緩老年人太早退出職場、依賴他人、失去工作/生活能力等等情形，使高齡者在職場中適任於所擔任的工作，結合其豐富的工作經驗，除有利於製造生產，更可以解決部分就業安置與部分的安養問題，及高齡健康的照護問題。從這次研討會來看，更在一次顯示肌肉骨骼傷病的相關問題的研究，不論是在日常生活或是職場中，都是近年來也都是各國關注的主要議題，如何強化評估技術，提供預防策略與建議，降低肌肉骨骼傷病，良好的工作場所設計及作業設計，以促進勞工健康，與減少職災給付，提升生活福祉，一直是各國重要的工作。而這些相關資訊，可將其與本所現行發展中之人因工程相關

研究相結合，並於本所日後召開人因工程領域專家會議時，提供給與會專家參考，配合本所現在與未來任務規劃，擘劃本所未來人因工程之優先研究議題與方向，除與國際研究趨勢接軌以外，且能協助勞工改善作業環境、增進績效與避免人因工程危害的發生。再者因應國家未來發展趨勢及本所之未來發展，未來有關人因工程的研究發展部分，我們可以關注及發展的優先議題包括：

(1) 加強運用智慧新科技，包含應用影像辨識技術、機械深度學習及人工智慧演算，以簡化技術實施的難度，強化人因性危害預防風險評估管理。

(2) 推動「合宜的工作設計」，考量及尊重個體化差異，以人為本工作設計理念，導入職安法中有關人因性危害預防計畫的指引裡。尊重弱勢勞工在職場的特別考量，且為特別的工作負荷考量及排程設計。加強應用科技輔具、管理技術及教育訓練，消除工作的不利因素。結合政府及業者的努力，導入科技輔具及合理排程，降低工作負荷。

(3) 關注心理社會問題在人因工程的潛在風險，實施疑似高風險族群的基線調查，應用科技技術實施人性化管理方法，以避免或減輕從心理面誘發職業災害風險。

肆、　攜回資料名稱及內容

大會手冊、本次研討會重要論文電子檔資料。

附錄一 本所發表之論文

Investigation of the Use of Work Assistive Devices by Caregivers in Long-term Care Facilities

- *Zhi-Xuan Chen, Ching-Chung Chen, Eiwen Lo, Liwen Liu, Pei-Chun Tu, Chih-Yong Chen*

SUMMATIVE STATEMENT:

This study primarily investigates the usage of work assistive among caregivers in long-term care facilities. The results reveal that among the commonly used work assistive devices by caregivers, the butterfly transfer board and transfer turntable are unfamiliar to them. Among the work assistive devices they have seen and used, shower chairs are the most commonly utilized by caregivers, followed by transfer slides, automatic shower beds, lateral transfer beds, ceiling-mounted transfer lifts, and transfer sheets. Time constraints are the primary reason they are reluctant to use those assistive devices.

KEYWORDS: Caregivers, work assistive devices, long-term care facilities

PROBLEM STATEMENT:

The study indicates that up to 80% of caregivers experience musculoskeletal injuries. To reduce occupational musculoskeletal injuries among nursing home staff and caregivers, many countries advocate for the use of assistive devices, with Australia even implementing a No Lifting Policy (NLP). Evaluating the occurrence of occupational musculoskeletal pain in hospitals implementing the NLP, it was found that within 12 months, the rates of one or more sites of occupational musculoskeletal pain were lower in NLP hospitals compared to those not implementing NLP, at 24% and 44% respectively. As caregivers are frontline workers directly facing and serving the disabled person, the appropriate and proper use of assistive devices is necessary to reduce their workload and musculoskeletal injuries.

OBJECTIVE/QUESTION:

This study primarily investigates six long-term care facilities, focusing on caregivers' understanding of and utilization of assistive devices in their work.

METHODOLOGY:

This study conducted a survey to investigate caregivers' awareness and usage of assistive devices among personnel in six nursing homes, long-term care facilities, and nursing homes with care-oriented services.

RESULTS&DISCUSSION:

The research findings indicate that the majority of caregivers still use manual methods to assist with patient transfers. The butterfly transfer board, transfer turntable, and turning straps are assistive devices unfamiliar to caregivers. However, shower chairs, transfer slides, automatic shower beds, lateral transfer beds, ceiling-mounted transfer lifts, and transfer sheets are the most commonly used aids. Among them, transfer slides and lateral transfer beds are most frequently used for transfers between beds and shower chairs, while transfer sheets are primarily used for turning and patting during caregiving tasks. Finally, caregivers expressed that time constraints were the primary reason for their reluctance to use assistive devices, followed by insufficient availability of such devices to meet their needs.

CONCLUSIONS:

Currently, caregivers primarily rely on manual lifting to assist with patient transfers. Therefore, institutions should provide further education, training, and promotion of the use of assistive devices to reduce and minimize work-related injuries among caregivers. Time pressure remains the primary reason caregivers are reluctant to use assistive devices, making it worthwhile to explore further discussions to decrease the ratio of caregivers to patients.

Investigation on Workload and Muscle Injuries of Care Service Personnel under Different Shift Systems

- *Ching-Chung Chen, Eiwen Lo, Liwen Liu, Pei-Chun Tu, Chih-Yong Chen, Zhi-Xuan Chen*

SUMMATIVE STATEMENT:

Taiwan's population has entered the era of an 'aging society,' with the demand for care services gradually increasing. However, there is a clear shortage of manpower in the current care service sector, with the primary reason being the significant workload on care service personnel. Therefore, this study primarily aims to investigate the full-day work content and musculoskeletal injuries of care service personnel under different shift systems. The research findings reveal that tasks with the highest proportion of working time are related to daily living care, and care service workers primarily rely on manual handling for assisting with patient transfers. Thus, there is limited room for improvement in the work content of care service personnel.

KEYWORDS: Care Service Personnel, Shift System, Workload

PROBLEM STATEMENT:

With the rapid aging of the population and advancements in medical care, coupled with the steep increase in the prevalence of chronic diseases and disabilities, the population of individuals with disabilities is expected to increase significantly, leading to a growing demand for long-term care[1]. According to surveys, there will be a substantial increase in the demand for long-term care service personnel in Taiwan. Both domestic and international studies have shown that care service personnel in the long-term care industry face a high risk of occupational musculoskeletal injuries, which affects their occupational safety, health, and willingness to work [2-5].

In Taiwan, care service personnel work under either a three-shift system (8 hours per shift) or a two-shift system (12 hours per shift). Due to the highly diverse and complex nature of their work, which includes general administrative tasks, technical work, as well as personal hygiene and other daily living care tasks, understanding the full-day work content and workload of care service personnel in long-term care facilities through surveys and analysis is crucial. This helps in improving the utilization of human resources and the allocation of job

responsibilities for care service personnel.

OBJECTIVE/QUESTION:

This study aims to understand the full-day work content and musculoskeletal injury profiles of care service personnel under different shift systems. By investigating how different shift systems impact the work content, workload, and musculoskeletal injury occurrences among care service personnel, this research serves as a foundation for subsequent improvements in manpower allocation and work conditions.

METHODOLOGY:

This study conducted on-site investigations of the full-day 24-hour work content and musculoskeletal injury profiles separately for two types of privately-owned nursing homes: those operating under a three-shift rotation system and those operating under a two-shift rotation system. Additionally, interviews were conducted with two care service personnel to gain insight into their perspectives on the work content.

RESULTS&DISCUSSION:

For the two long-term care facilities studied, tasks related to daily living care comprised the highest proportion of work content. In the morning shifts, there was a noticeably higher frequency of patient lifting and transfer tasks. Conversely, in the evening shifts, care service personnel were involved in a higher number of activities such as turning patients, patting their backs, and changing diapers. Regarding rest periods, care service personnel on the night shifts of the three-shift system and the evening shifts of the two-shift system were able to enjoy relatively more and complete rest time. Care service personnel reported that the most uncomfortable area was the lower back, followed by the right shoulder. They attributed their discomfort primarily to work-related factors. The discomfort was mainly associated with assisting patients in getting in and out of bed and in and out of wheelchairs.

CONCLUSIONS:

Each institution has its own unique set of tasks, but on average, the highest proportion of work content in terms of time is related to daily living care tasks. In the morning shifts, there is a noticeably higher frequency of patient lifting and transfer tasks, while in the evening shifts, care service personnel are involved in a higher number of activities such as turning patients, patting their backs, and changing diapers. Care service personnel primarily rely on manual lifting for assisting patients with transfers. Therefore, institutions should provide further education, training, and promotion of the use of assistive devices to reduce and minimize work-related injuries among care service personnel. Ultimately, whether under a three-

shift or two-shift rotation system, there is still room for improvement in the ratio of care service personnel to the number of patients they care for.

The Investigation of Workload and Use of Different Assistive Devices for Nursing Assistants

- *Victor Eiwen Lo, Ching-Chung Chen, Liwen Liu, Pei-Chun Tu, Chih-Yong Chen*

SUMMATIVE STATEMENT:

The purposes of this study were to conduct job analysis to understand the job contents and workloads. “daily care” task (e.g., assisting on wearing cloths, covering up the blankets, making the beds) is the most frequent tasks performed by the nursing assistants. Most nursing assistants manually perform transferring tasks and treat assistive devices as being reluctant to use due to time consuming. Training course shall be provide on the use of assistive devices to reduce the workload.

KEYWORDS: Workload, Assistive Devices, Nursing assistant.

PROBLEM STATEMENT:

According to previous studies’ results, nursing assistants working in long-term care facilities have suffered from higher risk of musculoskeletal disorders (MSDs). The relative high risk of MSDs raises the issues in the occupational safety and health as well as reduces their working intentions. In order to reduce the risks of MSDs for nurses and nursing assistants, many countries has implemented a guideline/standard on the use of assistive devices in long-term care facilities.

OBJECTIVE/QUESTION:

The purposes of this study were to conduct job analysis to understand the job contents and workloads.

METHODOLOGY:

We conducted 24-hour job analysis on six nursing homes or long-term care facilities (4 facilities with an 8 working hours per shift and 3 shifts per day (Type A); 2 facility with a 12 working hours per shift and 2 shifts per day (Type B)) and recruited 205 nursing assistants for NMQ and the use of assistive devices survey. Three researchers and 12 well-trained students conducted this study. At least 2 nursing assistants were recruited in a working shift. Before conducting the job analysis, the research team categorized all tasks into 11 groups based on the pilot study. An app named “WorkStudy+6 for Tums Study” (developed by Quetech Ltd.) was used to record the task and working time. Two students recorded the note and time on the tasks that each nursing assistant did.

RESULTS & DISCUSSION:

In Type A facilities that nursing assistants work in 3 shifts, “daily care” task (e.g., assisting on wearing cloths, covering up the blankets, making the beds) is the most frequent tasks performed by the nursing assistants in all three shifts, 27.62% (135.56 min) , 24.52% (117.73 min) , and 31.34% (162.83 min) in morning, night, and graveyard shift, respectively. Furthermore, the results from interviewing showed that the higher workload tasks are assisting showering, assisting transferring/relocating residents (bed to/from wheelchairs or beds), rolling over, tapping back, and changing diapers. Based on the results from job analysis and interviews, nursing assistants work in the morning shift usually suffer higher workload compared to those who work in the nigh or graveyard shift. The possible reason is tasks such as assisting the residents to take showers and assisting daily activities usually occurred in the morning shift, and these tasks required huge amounts of physical efforts. The frequency on transferring/lifting residents were 15.63 times in the morning shift, and it was higher than the frequency of 4.88 times in the night shift and 1.25 times in the graveyard shift. The frequency of tasks for “rolling over, tapping back, and changing diapers” in the graveyard shift was 4.55 times which was less than the other 2 shifts.In terms of the 2 facilities that nursing assistants work in 2-shift, the task on daily living care still ranked first among all tasks. Regarding to the tasks on the transferring and lifting residents, the numbers and duration performed by the nursing assistants in the day shift were significantly higher and longer than that in the night shift. Regarding to the tasks for “rolling over, tapping back, and changing diapers”, the durations in the day and night shifts were almost the same, 11.6% (73.41 min) and 9.96% (74.38 min), respectively. On the other hand, the numbers performed by the nursing assistants in the night shift (43 times) were significantly greater than the numbers in the day shifts (26.75 times). In the 2 facilities in 2-shift, the resting duration in the night shift was longer than the day shift.Regarding the assistive tools/equipment commonly used by nursing assistants, bath chairs are the most commonly used tools, followed by transfer sliding mats (slides), automatic bathing beds, parallel shift beds, and electric suspensions lifters and shifting slides. Electric suspension lifts are pointed out by most nursing assistants as being reluctant to use due to time consuming. Therefore, nursing home managers should provide further education, training and promotion of the use of work assistive devices to reduce the work injuries of nursing assistants.

The strength of this research is we recorded all the activities performed by the nursing assistants among six nursing care facilities, including task performance time. The limitation is we

did not conduct risk assessment on these task, instead of using subjective ratings. To determine the association between the risk exposure and discomfort prevalence is recommended for future study.

CONCLUSIONS:

We propose a draft of the “Guideline on the Use of the Assistive Devices for Nursing Assistants” based on the results from the study results on the “nursing assistant training courses,” “24-hour job analysis,” and “survey on the MSDs and the use of assistive devices by the nursing assistants” in this study. Additionally, we also provide the instructions on the use of the assistive devices, e.g., powered portable lift sling, lateral transferring beds, slide boards, slide sheets, roll-over belts. Moreover, videos have been made on the use of powered portable lift sling, lateral transferring beds, bath cart with slide boards for training courses.

LOWER BACK LOADING ESTIMATION BASED ON DYNAMIC IMAGES OF WORKERS PERFORMING MANUAL LIFTING

- *Pin-Ling Liu, Chien-Chi Chang, Pei-Chun Tu, Li-Wen Liu, Chih-Yong Chen*

SUMMATIVE STATEMENT: This study constructed a simulated lifting task scenario based on real-world field survey results. A validation experiment was conducted in this setting to investigate the feasibility of estimating lower back loading using dynamic images during manual lifting tasks.

KEYWORDS: Lifting, Field survey, Lower back, Dynamic image

PROBLEM STATEMENT: Manual lifting tasks remain crucial for productivity in many industrial settings. Lifting activities are considered one of the risk factors for occupational lower back injuries, leading to significant work-hour losses and costs (Ferguson et al., 2019). It is important to identify personnel working postures and assess their risk level based on the lower back loading estimations in the workplace. This approach enables the development of effective interventions to prevent lower back injuries.

With advancements in image recognition technology, a variety of image-based pose recognition methods have emerged. These methods generally offer cost-effective solutions that do not require large space or the attachment of markers to personnel's skin, thus reducing interference with real work situations. However, the feasibility of applying these methods for real-time assessment of lower back loading in field settings requires clarification before practical implementation. Furthermore, conducting verification experiments in an environment similar to actual working conditions would yield more compelling insights.

OBJECTIVE/QUESTION: This study conducted a field survey and developed a simulated lifting scenario based on the survey results for subsequent experiments. The feasibility of estimating lower back loading based on dynamic images was investigated.

METHODOLOGY: A total of 11 male workers, whose regular job duties involve repetitive lifting tasks, were recruited in this study (age: 35.55 ± 6.18 years; height: 172.64

± 8.17 cm; mass: 82.36 ± 12.12 kg). This study comprised two phases: a field survey followed by a validation experiment. All participants were asked to fully engage in both phases of the study, though data from only 10 participants were collected during the second phase.

During the first phase, researchers visited the participants' workplaces to observe and interview them regarding their job tasks, including the weight and dimensions of lifted objects, lifting frequency, and their subjective perception of musculoskeletal loads. Based on this data, a simulated lifting scenario was established in a laboratory setting. In the second phase, participants performed symmetric lifting tasks in the simulated scenario. They were instructed to lift a 15 kg box from a simulated pallet with a 10 cm height to a shelf at a height of 90 cm, with no constraints on the lifting path. Postural data were captured throughout the experiment using an optical motion tracking system. Meanwhile, dynamic images were recorded during lifting intervals, with participants' body keypoints identified via a skeleton recognition algorithm.

Postural data captured from the motion tracking system were input into biomechanical software (Visual3D, C-Motion Inc., USA) to obtain reference data for lower back joint loading. Body keypoints data from dynamic images were utilized to estimate participants' lower back loading using a top-down approach (Hof, 1992). The maximum resultant moment at the L5/S1 joint throughout the lifting duration was used as the indicator. The feasibility of estimating lower back loading based on dynamic images was evaluated by comparing these estimates with reference data.

RESULTS: According to the results of the field survey, six out of the eleven participants reported past musculoskeletal discomfort attributed to their work. Regarding their current work conditions, the average load level in the lower back region was the highest among the six body regions assessed (neck, upper limbs, lower limbs, upper back, lower back, and buttocks), with a maximum score of 5 and an average of 2.27. Throughout the entire lifting duration, the maximum resultant moment calculated based on reference data was 200.88 ± 57.64 Nm, while the maximum resultant moment estimated from dynamic images was 181.22 ± 72.58 Nm. Similar trends were observed in the variations of lower back loading values during the lifting process.

DISCUSSION: The survey results indicated that lower back discomfort remains an

ongoing issue requiring continued attention. This study found a tendency for underestimation in lower back load estimation based on dynamic images, with an underestimation of approximately 17.85%. Correction methods, such as regression models, warrant further development in the future. However, there were several limitations; all participants were from the same company. Whether other businesses requiring repetitive lifting tasks have similar working environments requires a broader investigation. Besides, most participants in this study had a body mass index above the normal range, falling into the obese category. The effect of different body types on the results was not examined.

CONCLUSIONS: Estimating lower back loading based on dynamic images provides a potential alternative assessment method for lifting tasks.