案例報告

工作現場人因工程改善建議方案——以食品配料作業爲例

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摘要

職業性肌肉骨骼傷病(Work-Related musculoskeletal disorders, WMSDs)在國際間已成為最常見的職業疾病，並花用最多的醫療及產業資源。肌肉骨骼傷病之產生，已知與工作場所人因工程設計之不良有高度相關性，學界普遍認為因工作所引起的肌肉骨骼傷害有5個主要成因：過度施力、高重複動作、振動、低溫、以及不良的工作姿勢。這五個成因之中只有不良的工作姿勢比較容易改善，而其餘的四個成因則難以輕易改變。工作姿勢不良，容易造成頸、肩、腰、腕等關節部位的痠痛、疲勞以及疾病。要消除這些痠痛、疲勞、疾病，可以採行人因工程的技術來改善工作場所設施及環境，讓勞工得以採行最自然而且省力的機能工作姿勢。本文利用人因工程改善技術改善工作現場姿勢不良的問題，並以(KIM, Key Indicators Method)人工物料處理檢核表加以驗證改善效益，研究結果顯示改善案例的風險值有明顯的下降，食品配料裝作業風險等級由3級降為2級，降低了人員肌肉骨骼傷害的風險。因KIM人工物料處理檢核表為明確、易用的檢核表，可以適用於大多數的抬舉或放置、握持、運送、以及推拉等作業，其使用上較為精簡，僅有三個步驟，非常適合現場快速診斷評估。

關鍵詞：肌肉骨骼傷害、人因工程、現場改善

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前言

大部分的人一生中皆有肌肉或骨骼傷害的經驗，依據我國勞工安全衛生認知調查，約有40%認為傷害與工作有關[1]，而造成肌肉骨骼傷害的主要原因，是工作姿勢不良，主要會造成頸、肩、腰、腕等關節部位的酸痛、疲勞以及疾病，因工作而引起的肌肉骨骼傷病(Work-related Musculoskeletal Disorders; WMSD)，雖然不會對患者造成生命的危險，但由於此類疾病的盛行率高而且病期長，是造成勞工「失能」(disability)的主要因素，且肌肉骨骼傷病易造成勞工行動上不便及持久不適，影響勞工的生活品質，另外因罹患肌肉骨骼傷病而使勞工收入減少，且勞工補償金額與醫療費用逐年提高，相對所造成的社會經濟負擔因而遠超過其他的職業疾病，因此肌肉骨骼傷病的問題不容小覷。工作所引起的肌肉骨骼傷病也是耗費最多資源的一種職業疾病，而肌肉骨骼傷病之產生，已知與工作場所人因工程設計之不良有高度相關性，由勞工保險職業病給付中發現，肌肉骨骼傷害佔第一位，單就職業性下背痛而言2007年86件、2008年109件、2009年136件，而手臂頸肩疾病也從2007年的98件，增加到2009年的239件之多[2-7]，不論人數或比例都有逐年上升的趨勢（如表1）。造成肌肉骨骼傷害的原因是多重的，舉凡振動、低溫、不當的姿勢、過度的施力、與高重複性的動作等因素，以及長時間暴露等，皆是造成工作上累積性傷害的主要原因[8]。我國於民國85年開始實施之肌肉骨骼傷害相關職業病診斷，給付項目包括勞工保險職業病種類表第6類第1項之雷諾氏病(Raynaud’s disease)及勞工保險職業病種類項目第3類之8項疾病，包括長期壓迫引起的關節滑囊病變、長期以蹲跪姿勢工作引起之膝關節半月狀軟骨病變、壓迫造成之神經麻痺（如職業性腕道症候群等）、因長期工作壓迫引起的椎間盤突出、長期工作壓迫引起的頸椎椎間盤突出、肌腱腱鞘炎、全身垂直振動引起的腰椎椎間盤突出、以及旋轉肌袖症候群等項目。

表1　我國歷年度肌肉骨骼傷害給付總計表

項次／年份	職業病下背痛給付人次	手臂頸肩疾病給付人次	肌肉骨骼傷害給付總計	勞工保險職業病給付總計	肌肉骨骼傷害佔職業傷害百分比
2004	53	85	138	328	42.07%
2005	47	64	111	213	52.11%
2006	61	87	148	267	55.43%
2007	86	98	184	275	66.91%
2008	109	182	291	387	75.19%
2009	136	239	375	478	78.45%

資料來源：勞工保險局統計報表

人因工程檢核方法

因肌肉骨骼傷害的原因複雜，因身體某部位經年累月不斷執行某種動作所以又稱為「累積性傷害」，為了要確定造成勞工傷害的因子與部位，學者們紛紛提出許多的評核危害因子的方法。在工業應用上，為了方便與快速的瞭解可能造成作業員肌肉骨骼傷害之因子與部位，人因工程檢核表因應而生，檢核表的主要評估項目為工作姿勢、施力大小、持續時間與頻率等。一般常使用的檢核評估方法包括肌肉骨骼傷害人因工程檢核表(Work-related Musculoskeletal Disorders)[9]、快速上肢評估法(Rapid Upper Limb Assessment)[10]、人因基準線風險認定檢核表(Baseline Risk Identification of Ergonomic Factors)[11]、北歐肌肉骨骼傷害問卷(Nordic Musculoskeletal Questionnaire)[12]、生物力學分析法[13]等；其中以關鍵指標法(Key Indicators Method)使用之人工物料處理檢核表較適合現場作業改善，因其用法較為精

簡且可快速預期評估改善成效，並容易被勞工安全衛生業務主管與管理員所接受者。故本研究採行機能工作姿勢搭配關鍵指標法KIM人工物料處理檢核表作一分析。

1. 機能工作姿勢

機能工作姿勢就是「自然」且「省力」的工作姿勢，其基本概念為盡可能的保持上身正直，避免過度的低頭和彎腰，特別是頭頸和腰部，並且以越靠近身體範圍工作越好，才不會增加工作負荷。

工作姿勢若能越接近機能工作姿勢，則其工作負荷越低，相對於MVC(Maximal Voluntary Contraction)的比例越低。所謂MVC，為最大自主收縮出力，各肌肉有其對應之MVC。無論靜態或動態動作，若工作力量需求小於MVC的比例越低，則人體不易感到疲勞疲勞，工作可以持續進行；反之，則會導致疲勞、痠痛，甚至發炎，最終累積成肌肉骨骼傷害。

在標準的站立姿勢，頭的重量基本上是沿著鉛錘方向作用在第7節頸椎(C7)前方，也就是頸椎的最下面一節中心的前方處。作用在第7節頸椎上的力量主要是頭和頸的重量所產生的壓力(Compression force)，即便有些微的向前力矩產生，而必須由頸椎後面的伸展肌(extensors)來平衡以維持姿勢的穩定，然而其力量都在15%的MVC以下，任何的作業人員，無論男女，即使長時間的工作都不會感覺疲勞與不適[14]。然而要是頸部逐漸向前屈曲，則作用在第7節頸椎上的向前力矩就很顯著的逐漸加大，當頭頸向前屈曲15°時，頸後伸展肌的出力必須達到7%的MVC，45°時20%的MVC，70°時25.5%的MVC（圖1）。

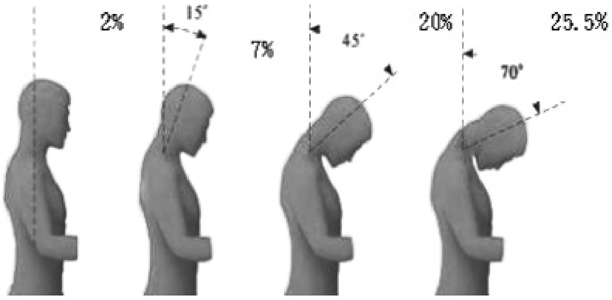


圖1　頭頸屈曲角度與MVC關係圖

軀幹也是一樣的要儘可能的維持正直的直立姿勢，當我們採取正直的站立姿勢時，上身的重量沿著脊柱，經由骨盆傳遞到腳而落在兩腳的中間位置。作用在脊柱、骨盆和腳等的力量主要是由軀幹重量所產生的壓力。如果上身向前逐漸屈曲，則軀幹的重心逐漸的向前移，也就是重心對於脊椎，特別是第五節腰椎與第一節薦椎之間的L5/S1關節；或是對於骨盆與大腿交接的髖關節(Hip joint)的力臂也隨之變大。在L5/S1關節與髖關節產生的向前力矩，這個力矩一定要由背肌群(erector spinae muscles)來抗衡以維持姿勢的穩定。當軀幹向前屈曲30°時，背肌群的出力必須達到16%的MVC，60°時28%的MVC，90°時33%的MVC（圖2）。

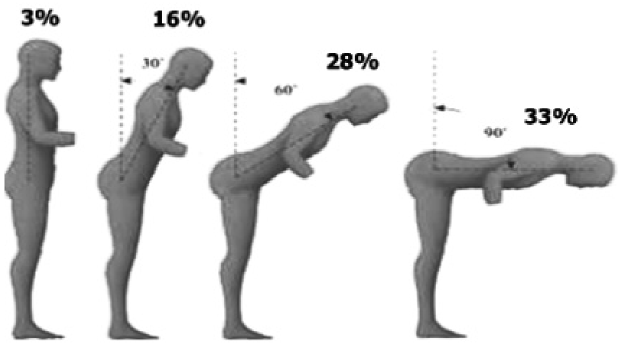


圖2　軀幹屈曲角度與MVC關係圖

2. KIM 人工物料處理檢核表

Key Indicators Method(KIM)是由德國所發展的檢核表，近年經北歐挪威、丹麥、瑞典等各國驗證後採納使用，於2001、2002年分別針對「人工物料處理」及「推拉作業」發表2個版本，考量工作姿勢、作業次數、持續時間、作業距離及荷重等因素[15]。KIM在使用上極為精簡，僅有三個步驟，非常適合現場快速診斷評估。但如果有數個不同的活動皆具有相當的生理壓力，就必須將不同作業分別進行估計。

步驟一先依作業特性，於表2中選擇「抬舉或放置作業」、「握持作業」、「運送作業」其中的一欄，並於該欄中選擇適當的作業次數／時間／距離，並對照讀取表中相對應的時間評級點數。

表2　KIM人工物料處理檢核表步驟一

抬舉或放置作業(<5s)		握持作業(>5s)		運送作業(>5m)	
工作日總次數	時間評級點數	工作日總時間	時間評級點數	工作日總距離	時間評級點數
< 10	1	< 5 min	1	< 300 m	1
10 to < 40	2	5 to 15 min	2	300 m to < 1km	2
40 to < 200	4	15 min to < 1 hr	4	1 km to < 4 km	4
200 to < 500	6	1 hrs to < 2 hrs	6	4 to < 8 km	6
500 to < 1000	8	2 hrs to < 4 hrs	8	8 to < 16 km	8
≥ 1000	10	≥ 4 hrs	10	≥ 16 km	10
範例：砌磚，將工件置入機器，由貨櫃取出箱子放上輸送帶送帶		範例：握持和導引鑄鐵塊進行加工，操作手動研磨機器，操作除草機		範例：搬運家具，運送鷹架至建築施工現場	

步驟二依序於表3至表5決定荷重、姿勢與工作狀況之評級點數：

表3　KIM人工物料處理檢核表步驟二-1

男性實際負荷[1)]	荷重評級點數	女性實際負荷[1)]	荷重評級點數
< 10 kg	1	< 5 kg	1
10 to < 20 kg	2	5 to <10 kg	2
20 to < 30 kg	4	10 to <15 kg	4
30 to < 40 kg	7	15 to < 25 kg	7
≥ 40 kg	25	≥ 25 kg	25

表4　KIM人工物料處理檢核表步驟二-2

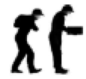
典型姿勢與荷重位置	姿勢與荷重位置	姿勢評級點數
	・上身保持直立，不扭轉。 ・當抬舉、放置、握持、運送或降低荷重時，荷重靠近身體。	1
	・軀幹稍微向前彎曲或扭轉。 ・當抬舉、放置、握持、運送或降低荷重時，荷重適度地接近身體。	2
	・低彎腰或彎腰前伸。 ・軀幹略前彎扭同時扭轉。 ・負荷遠離身體或超過肩高。	4
	・軀幹彎曲前伸同時扭轉。 ・負荷遠離身體。 ・站立時姿勢的穩定受到限制。 ・蹲姿或跪姿。	8

表5　KIM人工物料處理檢核表步驟二-3

工作狀況	工作狀況評級點數
具備良好的人因條件。例如：足夠的空間，工作區中沒有物理性的障礙物，水平及穩固的地面，充分的照明，及良好的抓握條件。	0
運動空間受限或不符合人因的條件。例如：1、運動空間受高度過低的限制或工作面積少於1.5 m^2或2、姿勢穩定性受地面不平或太軟而降低。	1
空間/活動嚴重受限與/或重心不穩定的荷重。例如：搬運病患	2

步驟三將與此活動相關的評級點數輸入計算式中，即可評估該項作業之風險值：

(＿＿＿＿＿ ＋ ＿＿＿＿＿ ＋ ＿＿＿＿＿)×
(荷重評級點數＋姿勢評級點數＋ 工作狀況評級點數)×

＿＿＿＿＿ ＝ ＿＿＿＿＿
時間評級點數＝　風險值

基本上必須假設隨著評級點數的增加，肌肉骨骼系統超載的風險也會增加，但由於個人的工作技巧和績效差異，風險等級之間的界限是模糊的，風險的分類因此只能算是一個輔助工具。更精確的分析需仰賴人因工程專家的專業知識。根據於計算所得之風險值，可依表6進行粗略的評估。

表6　KIM人工物料處理檢核表步驟三

風險等級	風險值	說明
1	<10	低負荷，不易產生生理過載的情形。
2	10 ≤　<25	中等負載，生理過載的情形可能發生於恢復能力較弱者3)。針對此族群應進行工作再設計。
3	25 ≤　<50	中高負載，生理過載的情形可能發生於一般作業人員。建議進行工作改善。
4	≥50	高負載，生理過載的情形極可能發生。必須進行工作改善。

工作現場訪視

因在於工作場所的設計，未能符合作業人員的姿勢及體型，無法採行合理、自然且有效率的工作姿勢，而引致累積性的肌肉骨骼傷害，工作現場觀察並記錄勞工的作業過程，分析不良工作姿勢與作業現場的關係，評估作業現場改善的可行性[16]，為提高勞動安全及改善工作環境，協助提升事業單位對於人因工程之認知，應用人因工程危害改善評估技術，實地前往工廠進行現場訪視作業，就工作現場的人因工程現況，提出工作與設施的改善方案。訪視地點包括產線之相關工作站，訪視的主要目的為查訪工作現場，各工作站作業人員比較容易產生肌肉骨骼勞累的作業情況，同時依據現場所見，立即與現場主管進行改善意見交換，並拍攝相片攜回進行分析，以研擬改善建議報告。以下就某食品配料作業加以說明。

1. 現況觀察

此作業是將食品配料是依配料比例，分別舀取原料袋中的麵粉及原料桶中的糖漿或奶油等原物料，放入置於電子磅秤秤台上的秤料桶中，如圖3所示。這個工作站的主要設備是一個靠牆座地的電子磅秤，其右邊放置兩袋麵粉袋，左邊放置糖漿桶及奶油桶。電子秤為15cm高，LCD顯示表高度離地85cm。秤料桶直徑為30cm，高度為55cm（桶緣離地70cm）。麵粉袋放置在棧板上，棧板高15cm，舀料的高度介於15cm與70cm之間。糖漿桶及奶油桶也是放置在棧板上，棧板的高度也是15cm，舀料高度也是介於15cm與70cm之間。舀料杓子的直徑為15cm，握柄長為15cm。作業員為年輕男性，身高170cm，年紀約30歲。進行食品配料時，作業員右手握持短柄不鏽鋼的杓子，平均側身彎腰45°舀取麵粉、糖漿或奶油，放入秤料桶中，並同時以低頭45°的姿勢審視LCD顯示器上的讀數。每杓的重量在2kg以下。每天秤料105桶，每桶歷時3分鐘，其中2分鐘必須彎腰低頭，總工作時間315分鐘，總共歷時210分鐘的彎腰低頭。

圖3　食品配料作業情況

2. 危害分析

本項作業的主要危害因子是「不良姿勢」與「高重複動作」。本作業屬於握持作業，以KIM檢核表評估，時間評級點數為7（210分鐘），荷重評級點數為1（2kg以下），姿勢評級點數為3（彎腰45°與低頭45°），工作狀況評級點數為0，結果顯示風險值為28，風險等

級為3，評定為中高負載，生理過載的情形可能發生於一般作業人員，建議進行工作改善。

3. 改善方案

針對本項作業的主要危害因子，改善方案是麵粉袋與奶粉桶的底部高度調整為握拳高度。電子秤置於50cm高的鐵架上，使原料桶的桶緣高度為120cm，LCD顯示表高度提高為135cm。麵粉袋、糖漿桶及奶油桶置於70cm高的鐵架上，加上舀料杓子的直徑15cm，舀料的高度範圍為介於80cm～120cm之間，約與作業員腰際高度相同，是理想的作業高度範圍。這樣的改善可以使作業員舀取物料的整個過程中，能夠保持上身挺直，以最自然、省力的站姿工作，以降低彎腰的肌肉骨骼危害，如圖4所示。

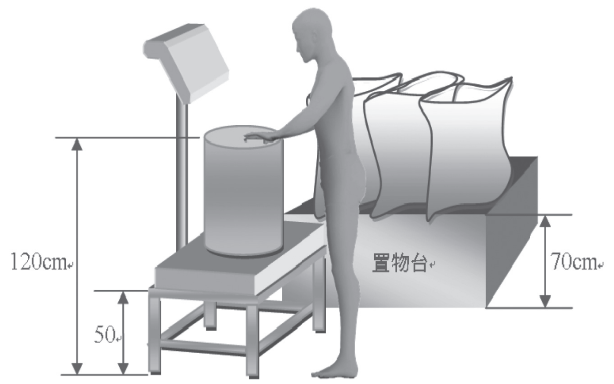


圖4　食品配料作業改善圖

4. 改善績效

本項作業經由上述的改善方式之後，利用KIM檢核表評估，時間評級點數仍然是7，荷重評級點數還是1，姿勢評級點數由3降為1（不再彎腰與低頭），工作狀況評級點數仍然維持0，結果顯示風險值由28降至14，風險等級由3降為2。食品配料作業改善後，105桶配料取料的時間由315分鐘降為280分鐘，工作效率提高16%，顯示改善效果明顯，改善效益如表7所示。

表7　食品配料作業改善效益評估

改善效益	時間評級點數	荷重評級點數	姿勢評級點數	工作狀況評級點數	總評級點數	風險等級
改善前	7	1	3	0	28	3
改善後	7	1	1	0	14	2

結論與建議

本文利用人因工程技術改善工作現場姿勢不良的問題，並以KIM人工物料處理檢核表加以驗證改善效益，現場執行改善作業時，常須考量改善成本及生產效益；經由機能工作姿勢搭配KIM人工物料處理檢核表分析，結果改善案例的風險值都有明顯的下降，分析訪視案例後得到結論與建議如下：

1. 從我國勞保給付資料顯示勞工肌肉骨骼傷害案例比例相當高，就職業性肌肉骨骼傷病工作致因來說，工作特性描述可以幫助了解該案例通常是暴露在怎樣的危險因子之下，因為勞工特定的動作或是行為長久累積下來而造成肌肉骨骼傷病的產生。
2. 肌肉骨骼危害防制必須結合人因工程知識與工程技術兩種專業技能，人因工程知識以生物力學和工作生理學的觀點，分析工作場所的人－機介面配合情形，研判肌肉骨骼危害的成因，提出理想的工作需求與限制，例如工作姿勢、動作頻率、施力大小等等；工程技術則是改善工作場所設法達成這些工作需求與限制。
3. 藉由工作現場人因工程改善技術，本文所舉之改善案例的風險值都有明顯的下降，以KIM人工物料處理檢核表加以驗證改善

效益，作業風險等級由3級降為2級，降低了人員肌肉骨骼傷害的風險。

4. 進行事業單位勞工職業骨骼肌肉傷害預防輔導，就現場肌肉骨骼危害，分析其作業危害成因，針對危害成因提出改善構想，評估改善成本及效益，整合出具有成本效益的改善方案。

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Case Study Reports

The proposed case of ergonomical intervention in workplace—Case for ingredients weighing

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Abstract

Work-related musculoskeletal disorders (WMSDs) have become the most common occupational diseases in the international workplace today. Among all occupational diseases, expenses are highest for WMSDs. It is known that poor ergonomic design in the workplace is an important cause of WMSDs, but studies of ergonomic factors in WMSDs in the workplace have been relatively scarce. It is generally agreed that the risk factors of WMSDs are over-exertion, high repetition, prolonged exposure, cold and vibration, and awkward posture. Among these five factors, four of them are not easy to alter except awkward posture. This posture may bring aches to the neck, shoulder, waist, wrist and other joints, or lead to tiredness and illness. To eliminate these aches, tiredness and illness, we can use ergonomics techniques to improve the installations and conditions in workplace so that laborers can work in a most natural and effortless posture. This study uses the techniques of ergonomical intervention to improve the bad posture in workplace and depending on Key Indicators Method (KIM) to check the benefit before and after the intervention. The risk of ingredients weighing is by level 3 become level 2. In general, The risk of case is significantly improved and eliminate the WMDS in

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workplace. KIM is a specific checklist and could be easily used in most operation such as lifting, holding, transporting and pushing-pulling etc. The estimation of KIM can be very brief, so it is appropriate to diagnose workplace in a short time.

Keywords: Work-related musculoskeletal disorders、Ergonomics、Workplace intervention

Preface

Many people have experienced musculoskeletal disorders. According to a survey of perceptions of safety and health in the work environment, it is considered that 40% of disorders arework-related[1]. The main reasonsbehind musculoskeletal disorders are awkward postures that bring aches, fatigue,and illness to the neck, shoulder, waist, wrist, and other joints when working. Althoughwork-related musculoskeletal disorders (WMSDs) pose mortality threats, their high prevalence and persistence remain major factors in the disability of laborers. In addition, WMSDs causeslong-term inconvenience and discomfort and eventually leads to poor quality of life. Furthermore, WMSDs may result in laborers' incomesdecreasing while workers' compensation and medical expenses increase, thus making a greater socioeconomic impact than other occupational diseases. Therefore, WMSDs are a serious issue that should not be easily overlooked. WMSDs also have the highest cost among various occupational diseases. It is known that musculoskeletal disorders are highly related with ergonomically bad designs in workplaces. From data of occupational medical benefit payments, it is noted that musculoskeletal disorders are the highest among all causes: the number of occupational lowerback pain cases were 86 in 2007, 109 in 2008, and 136 in 2009. The number of arm, neck and shoulder diseases also increasedfrom 98 in 2007 to 239 in 2009[2-7]. It shows that occupational disorder cases havebeen increasing year to year,whether it's in total number or in ratios (please refer to Table 1). Musculoskeletal disorders may be caused by multiple factors, including vibration, cold, awkward posture, overexertion, high repetition, and prolonged exposure. All above mentioned factors often lead to overuse injuries in workplaces[8]. In Taiwan, occupational musculoskeletal disorderdiagnosis practices have been implemented since 1996, and payments for diseases listed on the Schedule of Occupational Diseases for Labor Insurance 6-1includingRaynauds disease, and diseases listed on the Scheduleof Occupational Diseases for Labor Insurance 3-8, which including bursitis caused by prolonged pressure, meniscus injuries caused by prolonged squatting or kneeling, nerve paralysis caused by pressure (e.g., occupational carpal tunnel syndrome), cervical intervertebral disc herniation caused by long-term pressure in workplaces, tenosynovitis, lumbar intervertebral disc protrusion caused by vertical vibration, and rotator cuff syndrome.

Table 1 Total Payments for Musculoskeletal Disorders in Taiwan in Previous Years

Case / Year	Occupational lower back pain	Arm, neck and shoulder diseases	Musculoskeletal disorders	Occupational diseases under labor insurance	Percentages of Musculoskeletal disorders among occupational diseases
2004	53	85	138	328	42.07%
2005	47	64	111	213	52.11%
2006	61	87	148	267	55.43%
2007	86	98	184	275	66.91%
2008	109	182	291	387	75.19%
2009	136	239	375	478	78.45%

Source: Bureau of Labor Insurance

Ergonomics Inspection Methods

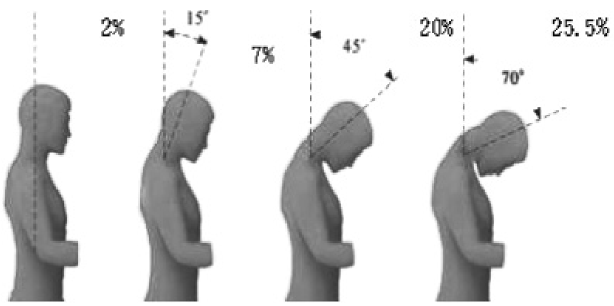
Factors of musculoskeletal disorders are complicated. Musculoskeletal disorders are often caused by body part damage due to performing highly repetitivemovements, and they are also called “overuse injuries”. To confirm the exact factors and body parts of occupational injuries, many researchers have tried to identify risk factors through various methods. In industrial applications, ergonomics inspection checklists are developed to understand factors and body parts of musculoskeletal disorders in a convenient and timely manner. On the forms, working posture, strength of force, duration and frequency are assessed. General inspection methods include theWMSDsErgonomic Inspection Form[9], Rapid Upper Limb Assessment[10], Baseline Risk Identification of Ergonomic Factors[11], Nordic Musculoskeletal Questionnaire[12], and the Biomechanical Analysis Method[13]. Among all assessment methods, the manual materials handling inspection checklist from the Key Indicators Method (KIM) is the most suitable for improving workplace conditions due toits simplicity, quick assessment and wide acceptance among labor safety and health managers and supervisors. In this research, the functional posture approach, supported by the KIM Manual Materials Handling Inspection Checklist, is utilized for analysis.

1. The Functional Posture Approach

Functional postures are postures that are “natural” and “comfortable.” The central idea is to keep the upper body as straight as possible to avoid excessivelylowering the head or bending down, especially the neck and the small of the back. In addition, it encourages laborers to be as close as possible when working to reduce burdens generated in work processes.

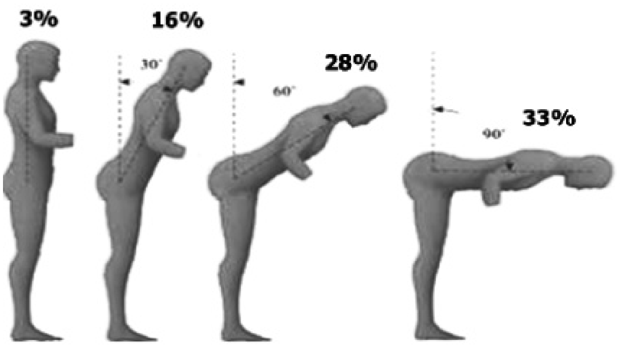
The more correctly one practices the functional posture in work, the smaller the burdenof the work, and thelower the relative ratio of maximal voluntary contraction (MVC). Every muscle has its own MVC whether in dynamic or static movements. If the strength of force needed to perform work is lower than the ratio of the MVC, then one›s body feels less tired. On the contrary, if the need is higher than the ratio of the MVC, then fatigue, aches, or even inflammation will eventually lead to musculoskeletal disorders.

In astandard standing posture,the head’s weight should run vertically along the front of the 7th cervical vertebrae (C7), which is in front of the center of the last cervical vertebrae. The main force on the C7 is mainly a compression force comingfrom the head and the neck. Some slight forces that move forward should be balanced by extensors behind the cervical vertebrae to maintain the posture. Other forces, however, should be lower than 15% MVC to avoid fatigueand discomforteven after a long working time[14]. Yet if the neck is continually bent, then the force on the C7 will drasticallyincrease, and when the neck forward flexion is 15°, the extensors at the back of the neck will contribute up to 7% of MVC, 20% of MVC when 45°, and 25.5% of MVC when 70° (Picture 1).



Picture 1 The Angle of the Neck and Its MVC Ratio

The body should also be kept as straight as possible. When we stand straight, the weight of the upper body, through the spinal column, the pelvis and thefeet, is inthe center between the feet. Forces on the spinal column, the pelvis and the feetare mainly generated by the weight of the body. If we keep bending down, the center of weight will move forward to the spinal column, especially on the L5/S1 joint, which is between the 5th lumbar vertebra and 1st sacral vertebra. In this scenario, the force arm on the hip joint, which is between the pelvis and the thighs, will also increase. The forward torque generated on the L5/S1 joint and the hip joint must be balanced by the erector spinae muscles to maintain posture. The force from the erector spinae muscles must reach at least 16% MVC when the body is bent forward to 30°, 28% MVC when 60°, and 33% MVC when 90° (Picture 2).



Picture 2 The Angle of the Body and Its MVC Ratio

2. KIM Manual Materials Handling Inspection Checklist

The Key Indicators Method (KIM) is an inspection checklist developed inGermany, and is certified and accepted by Norway, Denmark and Sweden. In 2001 and 2002, two additional versions regarding manual materials handling and push-pull operations were published respectively to better consider the factors of posture, frequency, duration, distance, and load[15]. KIM is simple to use,asit has only three steps and is suitable for a quick assessment. But if various activities with sufficient pressures exist, then multiple assessments of the respective tasks should be implemented.

Step 1: basedon the nature of the work, choose between "lifting/placing," "holding", and "carrying" from Table2, and pick the proper frequency/duration/distance. After that, find the corresponding time rating point.

Table 2 Step 1 of Using the KIM Manual Materials Handling Inspection Checklist

Lifting/placing (<5s)		Holding (>5s)		Carrying (>5m)	
Total frequency in working days	Time rating point	Total duration in working days	Time rating point	Total distance in working days	Time rating point
< 10	1	< 5 min	1	< 300 m	1
10 to < 40	2	5 to 15 min	2	300 m to < 1km	2
40 to < 200	4	15 min to < 1 hr	4	1 km to < 4 km	4
200 to < 500	6	1 hrs to < 2 hrs	6	4 to < 8 km	6
500 to < 1000	8	2 hrs to < 4 hrs	8	8 to < 16 km	8
≥ 1000	10	≥ 4 hrs	10	≥ 16 km	10
Examples: layingbricks, putting materials into a machine or moving a box from a container to a conveyer		Examples: holding and directing iron ingots to be processed, operating a grinding machine or operating a lawn mower		Examples: moving furniture, transporting scaffolds to a construction site	

Step 2: Use Tables 3, 4 and 5 to Identify Loads, Postures, and Work Condition Rating Points.

Table 3 Step 2-1 of Using the KIM Manual Materials Handling Inspection Checklist

Male worker's actual load[1)]	Load rating point	Female worker's actual load[1)]	Load rating point
< 10 kg	1	< 5 kg	1
10 to < 20 kg	2	5 to <10 kg	2
20 to < 30 kg	4	10 to <15 kg	4
30 to < 40 kg	7	15 to < 25 kg	7
≥ 40 kg	25	≥ 25 kg	25

Table 4 Step 2-2 of Using the KIM Manual Materials Handling Inspection Checklist

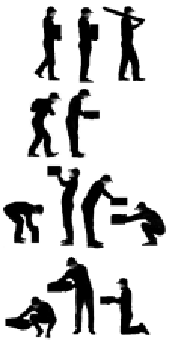
Classic postures and load positions	Postures and load positions	Posture rating point
	• Keeping upper body straight and avoiding any twisting • Keeping the load weight close to the body when lifting, placing, holding, carrying or lowering it.	1
	• Slightly bending forward or twisting • Keeping the load weight ata proper distance to the body when lifting, placing, holding, carrying or lowering it.	2
	• Bending lower or bending further forward • Bending the body forward and twisting • Keeping the load weight far above the shoulder	4
	• Bending the body forward and twisting • Keeping the load weight far from the body • Limited stability when standing • Squatting or kneeling	8

Table 5 Step 2-3 of Using the KIM Manual Materials Handling Inspection Checklist

Work condition	Work condition rating point
Good ergonomic conditions e.g.:sufficient space, no physical barriers existing in the working area, an even and stable floor, sufficient lighting and good condition for holding things	0
Partly limited space or insufficient ergonomic conditions e.g.: height of the space excessively low, working space that is less than 1.5 m2,or an overly soft, unsteady floor with an uneven surface	1
Extremely limited space or an unsteady center of weight e.g.:moving a patient	2

Step 3: Put relative rating points into this equation to assess the risk value.

(____________ + ____________ +
(Load rating points + posture rating points +
____________________)×
work condition rating points×
____________ = ____________
time rating points = risk value

Basically, the increase of rating points stands for the increase of the risk of musculoskeletal system overloads. But the boundary between risk ranks is thin due to personal working skills and different effectiveness. Therefore, this rank is only a supporting tool, and a more accurate analysis ofprofessional ergonomic skills needs to be made. One may make a rough assessment by finding the risk value in Table 6.

Table 6 Step 3 of Using KIM Manual Materials Handling Inspection Checklist

Risk rank	Risk value	Instruction
1	<10	Low load that won't likely lead to overloading.
2	10 ≤ <25	Medium load, weaker workers may find themselves overloaded.Suchwork should be re-designed for the weaker group.
3	25 ≤ <50	Medium-high load,general workers may find themselves overloaded. An improvement is suggested.
4	≥50	High load.Overloading is highly possible. An improvement is needed.

Visiting Actual Workplaces

An overuse musculoskeletal injury may occur when the design of a workplace cannot appropriately fit staff members postures and shapes and hinder them from adopting reasonable, natural, and effective postures. Via observing and recording laborers' work processes, and analyzing the relationship between bad postures andthe workplace itself, we can assess the possibility of improving the work site[16]. To better promote labor safety and workplace quality, improvement plans based on the ergonomic condition of the workplace need to be made through helping the working units to better understand ergonomics, applyingergonomic risk improvement and assessment skills, and actually visiting the work site or the factory. The places that need to be visited include the various production lines related to work sites, and the main goal is to identify work that may cause musculoskeletal fatigueor aches instaff. Based on observations at the work site, exchanging opinions with the supervisor should be performed in a prompt manner. In addition, photos should be taken for further analyses. After the visit, these data should be utilized to make a plan for improvements. The following are described with respect to a food product ingredient weighing task.

1. Observation

This process is to distribute various food product ingredientsof certain proportions. Raw materials such as flour, syrup and butter need to be placed in the barrel on the electronic scale weighing platform(Picture 3). The major equipment at this work site is an electronic scale against the wall. Two bags of flour are placed beside the scale,and a barrel of syrup with another barrel of butter are put on the left side. The scaleis 15cm high with an LCD screen that is 85cm high from the ground. The diameter of the barrel on the scaleis 30cm, its height is 55cm (the edge of the barrel is 70cm high from the ground). The flour bag is put on a 15cm high pallet and the height ofthe flour is between 15cm and 70cm. Two barrels of syrup and butter are also on a 15cm high pallet, with the same height of 15cm to 70cm. The scoop to transfer those raw materials has a 15cm diameter and its handle is 15cm long. The male staff member is 170cm tall, and he is about 30 years old. When weighing the raw materials, the staff member holds the short handled steel scoop in his right hand, and bends down to an average angle of 45° to transfer flour, syrup and butter to the barrel on the scale. At the same time, he has to read the number on the LCD screen with his head lowered to 45° . Every scoop is less than 2kg. Every day he needs to finish 105 barrels of such materials atthe rateof 3 minutes per barrel. In every three minutes of weighing, he has to lower his head and bend down for two minutes. As a result, he has to lower his head and bend down for 210 minutes in a total working time of 315 minutes.

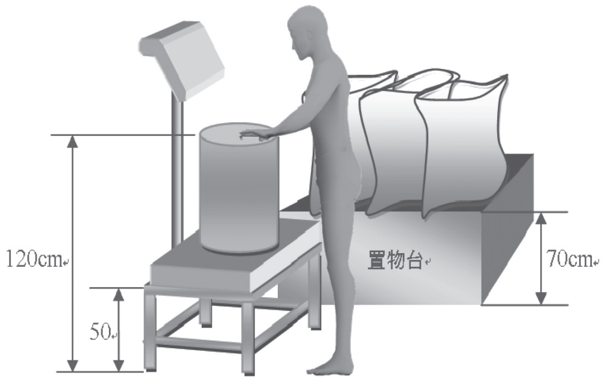
Picture 3: The Weighing Process

2. Risk Assessment

Major risk factors in this process are “awkward posture” and “high repetition.” This process is a holding and carryingtask. According to the KIM checklist, the time rating point is 7 (210 minutes), the load rating point is 1 (< 2kg), the posture rating point is 3 (bending at 45° and lowering the head to 45°) and the work condition rating point is 0. As a result, the risk value is 28 with a rank of 3 (Medium-high load, general workers may find themselves overloaded, an improvement is suggested.)

3. Plan for Improvements

Regarding the major risk factors in this case, the plan is to adjust the bottom height of the flour barrel and the milk powder barrel to the height of a fist. Put the electronic scaleon an iron rack 50cm high and make the height of the edge of the barrel 120cm high. The LCD screen is raised to a height of 135cm. The flour bags, syrup barrel and butter barrel are put on a 70cm high iron rack. The diameter of the scoop is 15cm, so the height of the materials being transferred is now between 80cm to 120cm, about the same height as the waist of the staff member, andan ideal height for the work. These improvements can keep the staff member›s upper body straight when weighing, and can work in the most natural and comfortable posture while avoiding the risk of WMSDs, as shown in Picture 4.



Picture 4 Improvements inthe Ingredients Weighing Process

4. Effects

After the improvements, the taskis assessed again by using the KIM checklist. The time rating point remains 7, the load rating point remains 1, the posture rating point decreases from 3 to 1 (no more bending and lowering), and the work conditions rating point remains 0. As a result, the risk value is lower, from 28 to 14, and the risk rank decreases from 3 to 2. After the improvements, the time spent in weighing 105 barrels of mixed raw materials decreases from 315 minutes to 280 minutes, a 16% improvement in the term of effectiveness. It shows that the improvement is obvious, as shown in Table 7.

Table 7 Assessment of the Improvements in the Ingredients Weighing Process

Effects	Time rating point	Load rating point	Posture rating point	Work condition rating point	Total rating point	Risk rank
Before	7	1	3	0	28	3
After	7	1	1	0	14	2

Conclusions and Suggestions

In this study, ergonomic skills are utilized to improve the issue of bad posture in the workplace, and the KIM Manual Materials Handling Inspection Checklist is used to evaluate the effect of improvement plans. When implementing improvement plans at a work site, one should always consider how to maximize the profit and effectiveness. Through the functional posture approach and the KIM Manual Materials Handling Inspection Checklist, the risk value of the studied case is clearly lowered. After analyzing the studied case, the author lists several conclusions and suggestions as follows:

1. From the data of payments under labor insurance, it shows that WMSDs ratio is relatively high. Among occupational musculoskeletal disorder factors, a detailed job description can help professionals to better understand under what risk factors the case is prone to. Musculoskeletal disorders may occur in laborers with certain postures or overuse.
2. To prevent WMSDs, both ergonomics and engineering knowledge have to be utilized. Ergonomics uses aspects of biomechanics and work physiology to analyze the relationship between staff and machines in workplaces and to judge risk factors of musculoskeletal disorders, proposing the ideal requirements and limitations, such as posture, frequency of the task, amount of strength, etc. Engineering technologies improve the workplace and address these requirements and limitations.
3. Via ergonomic improvement technologies, the case studied in this research sees a noticeable decrease in terms of risk values. Through the use of the KIM Manual Materials Handling Inspection Checklist, the effects of improvements can be evaluated. As a result, the risk rank is lowered from 3 to 2, and the risk of WMSDs is also lowered.
4. It is necessary to promote knowledge of the prevention of WMSDs in various organizations. Based on potential musculoskeletal disorder dangers in the workplace, risk factors in working processes should be identified and analyzed, and improvement plans regarding those factors should be submitted and properly assessed to form effective improvement plans.

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