

論文

造紙業藍領及白領從業人員肌肉骨骼不適與 勞動疲勞之比較研究

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摘要

研究目的：紙及紙製品為日常生活所需的用品，生產及製造流程需從業人員進行機器操作及手工製作，因涉及軀幹及肢體的施力及反覆動作會造成肌肉骨骼不適及勞動疲勞。本研究觀察造紙業從業人員，在三種工作性質（藍領勞動及反覆型、白領辦公型）肌肉骨骼不適與勞動疲勞的差異比較。方法：本研究採橫斷性研究法，針對北區某家中小型造紙業工廠，進行現場觀察及問卷調查，共計100份有效問卷。結果：在受訪的造紙業從業人員中，頸(佔25.7%)及背部(佔38.6%)為肌肉骨骼不適分佈最常見部位。工作性質與自覺疲勞程度有統計相關，藍領較白領更易感到經常或總是感到疲勞，且持續6個月以上有疲勞感的藍領佔89.4%為最多；輪夜班(23PM-7AM)時間及上班第一日皆是藍及白領最感疲勞班次及日數。勞動型與反覆型藍領員工多數在生產線現場，暴露較多的身體負荷及環境噪音、室溫、輪班等疲勞來源，白領員工耗損較多精神壓力，睡眠及休息不足。結論：造紙業從業人員因工作性質暴露源不同，藍領及白領員工在肌肉骨骼不適及疲勞成因具有差異，建議職場關注工作產生的疲勞因素，提供員工減少肌肉骨骼傷害的健康促進計畫，有效降低肌肉骨骼傷害及疲勞的發生。

關鍵詞：造紙業、藍領及白領從業人員、肌肉骨骼不適、勞動疲勞

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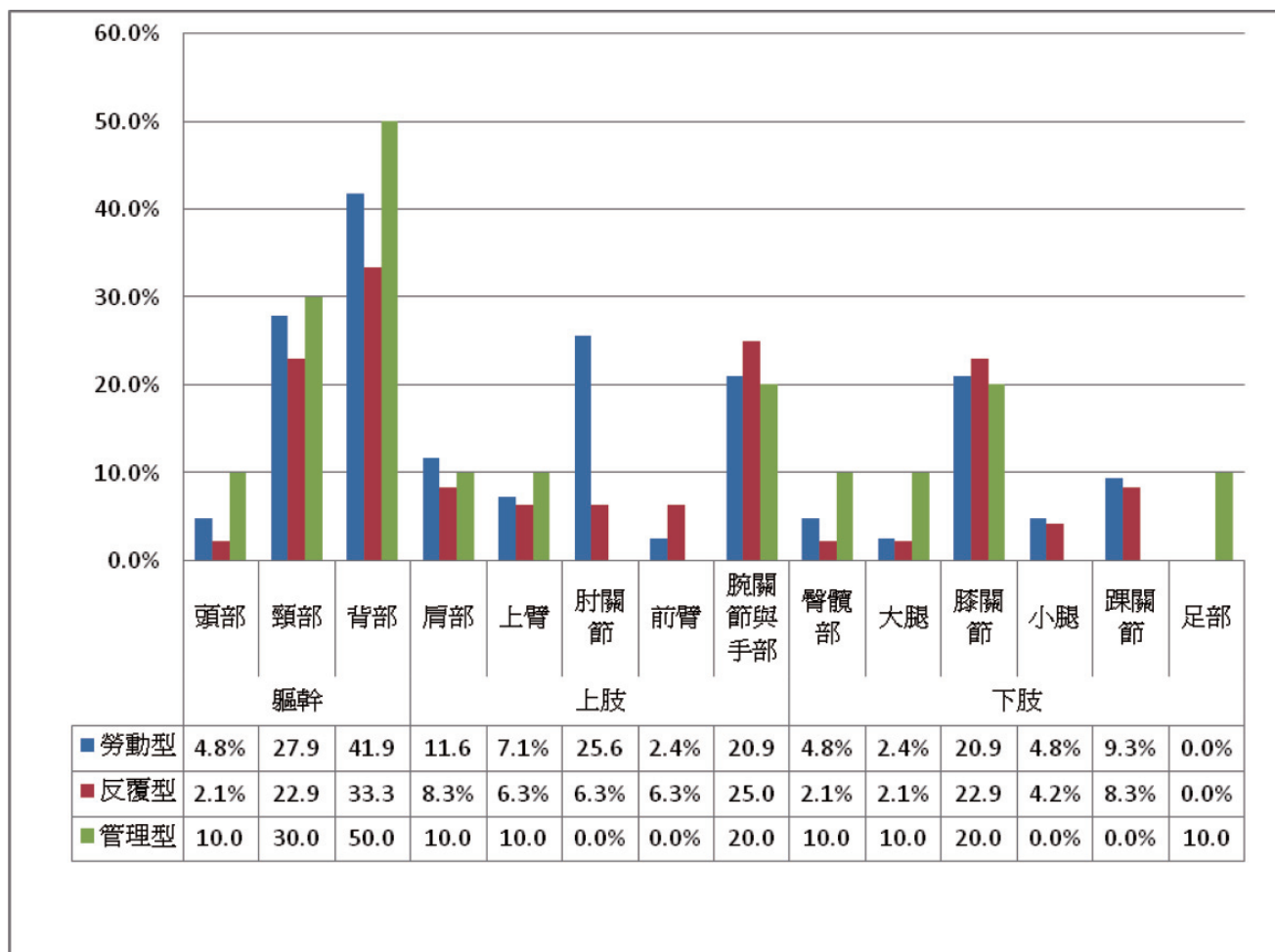
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緒言

紙漿及造紙設備操作人員工作性質，主要從事於紙漿、紙原料、紙類製品的製造，根據勞工委員會職類別薪資調查資料顯示[1]，民國101年7月國內受僱人數為14,836人。因生產製程常需進行紙漿調製執行、厚紙板裁切、摺疊、釘車、網綁，長時間反覆動作及搬運紙類製品等耗用體力勞動工作。對於反覆性及耗費體力的勞動工作，是引起肌肉骨骼疼痛問題的來源之一[2]，許多研究也證實工作的生理負荷，包括：繁重的工作量、靜態姿勢、頻繁的彎曲和扭曲不良姿勢、提重物、推、拉、搬

運、重複性的工作，影響肌肉骨骼疼痛的發生[3-5]。特別在反覆性工作，容易增加工作者在肩、頸、上肢的疼痛[6,7]，疼痛症狀通常在6-12個月的工作期間發生[8]。中度及重體力工作因經常保持在相同姿勢、及有限的肢體關節活動範圍，為維持一定的生產作業速度，使肌肉持續收縮產生肌肉疲勞及疼痛，容易發生在肩、背、臀部及膝蓋不適部位。多篇研究顯示，從事中度及重體力工作的藍領勞工，肌肉疼痛症狀和臨床診斷發病率較白領勞工高[9]，Schreuder KJ's研究發現，藍領勞工下背痛比白領較為明顯，其原因是暴露較多的身體工作負荷，及抬舉與拖曳較重的物品和長期彎曲的不

圖1 造紙業不同工作屬性員工肌肉骨骼不適身體發生部位



良姿勢[10]。Jansen JP 研究以769位護理之家照護員，計算每星期工作時間在軀幹屈曲超過20°、45°與升降或搬運的負荷超過10公斤的累積性物理負載暴露量，和下背痛的結果放入線性統計模型估計，發現軀幹彎曲超過45度和抬舉承載超過10公斤的身體負荷與下背痛呈現劑量反應效應[11]，進一步證實與工作相關的健康不適的結果與身體職業危害因素。

疲勞是由於過度勞動所引起，且會伴隨著一種獨特疾病感的肉體機能減退。疲勞可分心理與生理疲勞。心理疲勞會因個人缺乏動機、情緒、興趣或習慣造成。生理疲勞指體力負荷所引起工作有關的疲勞。對於形成疲勞的原因，涵蓋有作業內容（動／靜態肌肉負荷、精神緊張、作業單調）、作業環境（照明、溫度、活動區域、人因工程）、工作制度（工作時間約束、連續作業與休息時間之分配）、生活條件（受約束、半約束時間影響休閒生活）及工作適應能力（個人年齡與體能狀況）[12]。勞工安全衛生研究所（以下簡稱本所）2004年工作環境安全衛生狀況認知調查發現，行業別中以製造業工作者疲勞指數最高占42.7%[13]，「工作負荷」越高，疲勞指數越高[14]，身體工作負荷是形成肌肉骨骼不適的一個重要危險因素。葉婉榆曾對北市36家職場疲勞狀況調查，結果發現工作時間長短、工作負荷強度與密度是疲勞來源，其中又以藍領階層（尤其男性）最為明顯[15]。Song YK從300多位白及藍領階層勞工調查，發現白領階層有較高的精神心理工作要求，藍領階層體能要求較高[16]。

對肌肉骨骼不適研究，國內過去針對在汽車業、餐飲業、半導體業、面板業、醫療照護、飯店及旅館業房務清潔人員有做過相關研究[17]，對於紙漿及紙製品製造業產業論述較

少，研究以勞動型態及高頻次反覆性動作與白領之辦公工作特性更少。因此本研究以紙漿及造紙設備操作人員為研究對象，調查勞動型態、反覆性藍領及辦公白領階層勞動疲勞成因及其肌肉骨骼不適部位情況。

研究方法

1. 研究對象

紙製品的生產製程將木材或其他原料轉變為紙漿、再行調製、壓榨、乾燥、上膠，紙張的捲取、裁切和包裝。本次研究以立意取樣至國內北部某跨國企業的紙製品製造工廠收案，受訪的研究對象總計130名，有效樣本數為100名。依工作內容區分以下三種（如圖2、圖3）：

階層	工作型態	內容
藍領	勞動型	紙漿與造紙儀器設備操作，搬運紙漿重物及紙製品
	反覆型	配合生產線，進行紙製品裁切、摺疊、包裝與網綁
白領	辦公型	辦公室行政管理、電腦操作

研究工具

勞動疲勞調查由職場疲勞調查表，採結構式問卷包含疲勞程度、疲勞持續時間、輪班疲勞班次、自覺身體、心理最疲勞及最不疲勞的工作天、疲勞原因及症狀等。肌肉骨骼不適是利用北歐肌肉骨骼問卷（簡稱NMQ問卷）為基礎，信效度亦已被相關研究驗證[18-20]，進行造紙業作業人員因工作有關的肌肉骨骼不適包含頸部、肩膀、上背部、手腕/手部、下背部/臀部、大腿、膝蓋、小腿、足踝足部的調查。

統計分析

資料處理與統計以SPSS 17.0套裝軟體進行資料分析。以描述性統計呈現員工基本資料及不同工作性質之職場疲勞與因素，單因子變異



圖2 造紙業勞動型工作員工協助搬運紙漿重物及紙製品

圖3 造紙業反覆型工作員工協助紙製品裁切、包裝

數分析(one-way ANOVA)檢定三種工作型態之人口統計差異及卡方檢定(chi-square tests)分析不同工作屬性員工自覺疲勞之盛行率是否有顯著差異，統計顯著水準 α 訂為0.05。

結果

1. 造紙業不同工作性質員工之基本資料

本研究對象基本資料分析結果顯示，男性

64位，女性36位，平均年齡為47.4歲。3種工作型態之員工分佈，勞動型40位（占40%）、反覆型50位（占50%）及辦公型10位（占10%），性別、年齡、工作年資無顯著關聯，在休閒運動習慣，有57%的人從來沒有，43%的人有運動習慣。

2. 造紙業不同工作性質員工肌肉骨骼不適身體發生部位之盛行率

造紙業3種不同工作性質員工肌肉骨骼不適主要身體發生部位職業傷害以軀幹分佈最多，主要在頸部及背部不適(勞動型27.9% vs 41.9%)；(反覆型22.9% vs 33.3%)；(辦公型30% vs 50%)，「肘關節」不舒服以勞動型較反覆型明顯，「腕關節與手部」不舒服以反覆型較勞動型明顯，如圖1所示。

3. 造紙業不同工作性質員工自覺疲勞之盛行率

自覺疲勞程度與3種不同工作性質有統計顯著相關如表1，勞動與反覆型工作性質較辦公型，更易感覺經常或總是感到疲勞。疲勞持續時間及班次雖然在3種不同工作性質無統計顯著關聯，但發現勞動與反覆型員工疲勞持續時間為2-3天及6個月以上比例最多，呈現U型曲線二端趨勢；辦公型較集中在1個月至6個月內的時間。疲勞感持續6個月以上又以藍領勞動及反覆型員工最多；疲勞班次集中以輪晚班23PM-7AM時間最感疲勞（佔79.5%）。上班的五天時間內，無論在身體、心理上最感到疲勞日皆是在上班第一日（身體部分52.8%；心理感受46.0%），上班第五日為最不疲勞日（身體部分34.4%；心理感受57.3%），如圖4及圖5。

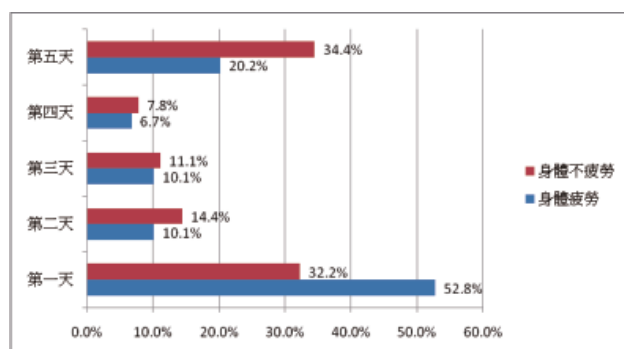


圖4 上班身體最疲勞與最不疲勞的天數

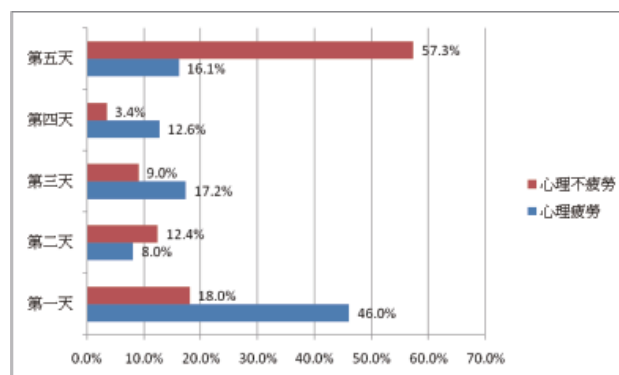


圖5 上班心理最疲勞與最不疲勞的天數

表1 造紙業不同工作屬性員工自覺疲勞之盛行率分佈

項目 工作性質	工作性質			總計	p value
	勞動型 (n=40)	反覆型 (n=50)	管理型 (n=10)		
疲勞程度					
總是	2	0	0	2	0.004
	5.0%	0.0%	0.0%	2.1%	
經常	5	5	0	10	
	12.5%	10.9%	0.0%	10.4%	
偶爾	18	38	9	65	
	45.0%	82.6%	90.0%	67.7%	
不常	13	1	1	15	
	32.5%	2.2%	10.0%	15.6%	
沒有	2	2	0	4	
	5.0%	4.3%	0.0%	4.2%	
疲勞持續					
2-3天	10	12	1	23	0.084
	31.3%	26.7%	11.1%	26.7%	
1週內	4	6	1	11	
	12.5%	13.3%	11.1%	12.8%	
1月內	0	5	1	6	
	0.0%	11.1%	11.1%	7.0%	
1月以上至3月內	2	2	3	7	
	6.3%	4.4%	33.3%	8.1%	
3月以上至6月內	2	4	2	8	
	6.3%	8.9%	22.2%	9.3%	
6月以上	14	16	1	31	
	43.8%	35.6%	11.1%	36.0%	
疲勞班次					
早班	5	5	2	12	0.062
(7AM-15PM)	14.7%	14.3%	50.0%	16.4%	
午班	1	1	1	3	
(15PM-23PM)	2.9%	2.9%	25.0%	4.1%	
晚班	28	29	1	58	
(23PM-7AM)	82.4%	82.9%	25.0%	79.5%	

造紙業員工普遍自覺疲勞原因有睡眠不足（佔54%）、輪班工作（佔34%）、室溫太高（佔31%）。工作性質的差異，辦公型員工工作負荷有明顯工作量較大、工作壓力緊張與用腦過度；反覆型員工有較高之肌肉疲勞比例、有部分的肌肉無力症狀；在勞動型與反覆型員工多數需輪班，須參與輪班的員工認為輪班工作是造成其感到疲勞的原因；在勞動型與反覆型員工多數在生產線現場，派駐於此工作場域的員工均覺得工廠環境中的噪音、室溫是關鍵的疲勞來源，如表2。

討論

由本研究造紙業人員三種工作性質的肌肉骨骼不適及勞動疲勞結果，發現無論在藍領勞動型、反覆型及白領辦公型員工，頸、腕關節與手部、背部為發生肌肉骨骼不適最嚴重部位。由於造紙業平日工作，常重覆製漿和各種材質的紙漿調製及各式紙品以半機器、半手工製作包裝/綑綁，特別容易在上肢（主要手/手腕）有過度及極端的重複動作及姿勢，凸顯在軀幹與上肢，為發生肌肉骨骼不適盛行率最多區域。過去有幾篇研究討論藍及白領工作者健康與工作負荷之差異，頸、肩關節不適的相關研究。Blader S等人調查4家紡織廠155位的生產線操作員，其中131人主訴有肩膀或頸部疼痛[18]。Onishiu N等人針對字型符號製造商、燈光師、感光膠片滾動工人、教師和辦公室員工之5組行業族群，評估手臂與肩膀的反覆動作，對於肩部肌群與肌肉骨骼不適症狀之比較。研究顯示此五種行業，在從事上肢反覆性操作頻率較高的工作者，比辦公型員工發生頸、肩關節不適有3.8倍之風險。因手臂與肩膀的反覆動作，會產生10%-30%頸部與肩部斜方肌最大自主性的收縮力，增加肌肉負荷對頸部與肩膀造成累積性肌肉疲勞，逐漸形成慢性肌肉骨骼不適局部壓痛的前兆症狀及發炎現象[19]。Ohisson K等人針對製造業女性工人，分組為82位有反覆性動作與64位無反覆性動作的頸部/肩部不適症狀比較，在多變量統計模型分析中，發現暴露在反覆型工作的實驗組較非暴露在反覆型工作的對照組，頸部不適症狀有3.6倍風險，被診斷有頸與肩部疾病者有4.6倍風險，張力性頸部疾病有3.6倍風險[7]。Burt S指出白領辦公族群，打字時注視著電腦螢幕，使脖子長期維持在靜態姿勢，沒有座椅旁支撐

表2 造紙業不同工作屬性員工自覺疲勞原因

原因	工作性質	勞動型 (n=40)	反覆型 (n=50)	辦公型 (n=10)	總計 (n=100)
工作負荷	工作量較大	7 10.0%	7 14.0%	3 30.0%	17 17.0%
	工作壓力與緊張	12 30.0%	14 28.0%	3 30.0%	29 29.0%
	費力工作	2 5.0%	2 4.0%	0 0.0%	4 4.0%
	用腦過度	0 0.0%	0 0.0%	3 30.0%	3 3.0%
	體力不足	0 0.0%	0 0.0%	2 20.0%	2 2.0%
工作適應能力	肌肉疲勞	0 0.0%	12 24.0%	1 10.0%	13 13.0%
	肌肉無力	0 0.0%	5 10.0%	0 0.0%	5 5.0%
	睡眠不足	17 42.5%	31 62.0%	6 60.0%	54 54.0%
恢復情形	無法好好休息	6 15.0%	6 12.0%	2 20.0%	14 14.0%
	生活壓力	8 20.0%	5 10.0%	0 0.0%	13 13.0%
	輪班工作	17 42.5%	16 32.0%	1 10.0%	34 34.0%
工作制度與模式	反覆操作動作	0 0.0%	5 10.0%	0 0.0%	5 5.0%
	噪音	13 32.5%	12 24.0%	0 0.0%	25 25.0%
環境因素	通風不良	5 12.5%	2 4.0%	0 0.0%	7 7.0%
	室溫太高	15 37.5%	15 30.0%	1 10.0%	31 31.0%

的扶手物件，手肘常在懸空下動作，容易增加頸、肩不適[20]。多數流行病學研究也發現，反覆型的工作不僅影響頸部活動也會涉及手和手臂。當手部的使用力量過度和反覆過度使用，超過組織的修復能力，產生手部肌腱和肌肉的損傷。Roelen CA指出手工密集的產業工人，工作流程密集的速度和加速度會顯著造成肌腱炎的發生[21]。

過去諸多文獻證實，包含重體力的工作、舉過重的物品、彎曲和扭轉的動作、全身振動與靜態工作姿勢工作相關的原因與下背痛發生有關。Marras WS指出當工作時承載過重的外力負荷，如進行人工物料的搬運加上抬舉重物，身體為抵消負載力矩，產生不自然強迫姿勢體位，或過度使用軀幹肌肉、韌帶和關節，無形壓迫、旋轉的力量，造成對脊椎椎間盤及周邊的肌肉組織的過度傷害[22]。瑞典針對八家公司共計209位白領和241位藍領工人，進行有關肌肉骨骼症狀，心理和體力負荷因素的問卷調查，分析藍及白領工作負載與身體肌肉骨骼症狀部位之間的相關性。研究發現金屬製造廠的藍領員工相較白領有1.8倍的下背痛風險，在評估藍及白領員工的工作負載因素，藍領員工經常發生有極端扭轉的工作姿勢，白領員工則顯現在靜態的工作型態中[23]。由瑞典另一項全國調查顯示，向前彎曲的姿勢產生下背痛呈1.3倍相對危險性，抬舉動作呈1.2倍、久站呈1.3倍。本研究在紙製品製造員工，因經常需要抬舉、推和搬運紙張或紙箱等重物，呈現本研究藍白領員工在背部為發生肌肉骨骼不適最嚴重部位。

本研究造紙業勞動疲勞結果由one-way ANOVA統計發現，3種不同工作性質在疲勞自覺程度、疲勞持續時間與輪班班次，以疲勞自覺程度具有統計顯著性($p < 0.05$)，其中藍領階

層的勞動型（佔17.5%）總是及經常自覺疲勞程度略高於反覆型（佔10.9%），疲勞持續時間傾向短期2-3天及長期6個月以上二端U型曲線趨勢分布，有持續6個月以上慢性疲勞藍領階層佔多數；Melamed et al.研究現藍領階層慢性疲勞較白領明顯[24]，此現象與本研究調查發現一致。

輪班性質夜班工作（晚上23時至早上7時），為本研究多數員工最明顯感受的疲勞班次。人體生理機能之日夜循環調節機制主要在腦部松果體，松果體受到光線週期的影響以維持白天與晝夜對促進大腦興奮與休息。輪班工作者，在夜間工作時雖有睡意，但卻要對抗生理反應，保持工作狀態的清醒，等下班後可以睡覺，卻因日間的生理活化狀態而變得清醒，影響睡眠深度，進而產生睡眠不足感覺[28]。

從本研究之調查發現，工作壓力與緊張、睡眠不足是3種不同工作性質共有的主訴疲勞來源。雖然3種工作型態具有部分疲勞成因上的差異，藍領現場操作人員，因在造紙製程中，常需使用化學原料、漿糊或膠水等，空氣比較污濁，工廠多數沒有冷氣空調，必須忍耐悶熱和機器運轉產生的噪音，輪班、環境噪音及室溫太高是藍領較白領階層感受明顯的疲勞原因；白領辦公人員主要在業績銷售及市場開發，工作量大、工作壓力與用腦過度的工作負荷為自覺疲勞比例較高的來源。此現象與Roelen CA發現白領工作者有較高心理工作要求，藍領以身體工作負荷較重發現一致[21]。本研究的調查無論藍及白領人員，皆呈現上班的第一天為身心最感疲勞的上班天數，顯示職場工作者在一週的工作期間，精神會處於較緊張狀態，休假時才有較多的時間，可以讓身心放鬆與休息；當休假結束，必須打起精神重新面對工作時，或多或少會出現疲倦、昏昏欲

睡、睡眠不足、難以集中精神工作等假期後症候群症狀，產生在上班第一天感到最為疲勞。

結論

本研究證實造紙業3種不同工作性質，影響肌肉骨骼疾病及疲勞成因的差異，藍領員工暴露較多的重體力、抬舉、反覆性的身體負荷，及噪音與高溫環境，肌肉骨骼傷害及慢性疲勞現象發生有較高的比例；白領員工在工作上耗損較多的精神壓力，睡眠及休息不足普遍發生。唯本次調查受限時間及人力限制，僅以單一家工廠進行研究為本研究限制，建議持續擴大造紙業之工廠家數與調查人數，增進對於職場中屬於勞動與反覆性的工作負荷在健康風險的差異，以瞭解員工肌肉骨骼傷害的危險因子；提供員工對肌肉骨骼傷害發生原因、保持工作良好姿勢的衛生教育宣導，提供運動方案（如伸展操、健身操、有氧運動），提升工作者所需的肌力、肌耐力與關節活動度，使員工擁有一個安全健康的工作環境，減少肌肉骨骼傷害及疲勞的發生及增進生產力。

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Research Articles

A Comparative Study of Work-related Musculoskeletal Disorders and Fatigue for Blue-collar and White-collar Employees in the Paper Manufacturing Industry

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Summary

Purpose: Paper and paper products are goods used daily in ordinary life. The production and manufacturing processes require manual handling and machine operation. Since the process involves the use of force and repetitive actions by the human body's limbs and torso, musculoskeletal discomfort and labor fatigue can develop. By investigating employees of the paper industry, this study provides a differential comparison of musculoskeletal discomfort and labor fatigue for three types of labor: blue-collar, repetitive, and white-collar.

Methodology: A cross-sectional study method is applied in this research. For a certain medium-sized paper manufacturing factory in the northern area, on-site observation and a survey was conducted with a total of 100 effective questionnaires.

Results: Among the paper manufacturing employees surveyed, necks (25.7%) and backs (38.6%) were shown to be the body parts where musculoskeletal discomfort occurs most often. The type of work and the self-aware level of fatigue are correlated statistically. Blue-collar laborers often or always experience fatigue, and those blue-collar workers who feel fatigued constantly for six months comprise the majority, 89.4%. Night shifts (23PM-7AM) and the first day of work each week are the shift and work day when both white-collar and blue-collar workers experience the most serious fatigue. Blue-

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collar employees of a laborious and repetitive work type spend most of their working hours on-site on the production line. Blue-collar laborers are more often exposed to source fatigue such as heavy workloads, environmental noises, high indoor temperatures, and moving, whereas the white-collar employees suffer more from weariness of mental strength, pressure, and lack of sleep and rest. Conclusion: Due to the different exposure sources of fatigue of the different work types among paper industry workers, the resulting factors of musculoskeletal discomfort and fatigue between blue-collar and white-collar employees vary. This study suggests that more attention should be paid to the factor of fatigue and health improvement programs in order to reduce employees' musculoskeletal injuries and thus effectively decrease any occurrence of musculoskeletal injuries and fatigue.

Keyword: Paper manufacturing industry, Blue-collar and white-collar employees, Musculoskeletal discomfort, Fatigue

Introduction

The scope of work of paper pulp and paper manufacturing facility operation workers mainly includes the production of pulp, raw paper materials, and paper products. According to the occupational wage investigation data of the Council of Labor Affairs[1], the hiring number in this industry is 14,836. During the production process, processes such as pulp formulation, cardboard cutting, folding, stapling, and tying require long-term repetitive actions, and the moving of paper products and other such tasks are energy consuming. Such repetitive and energy consuming laborious works are source of health issues like musculoskeletal pains[2]. Many studies have also proven that a physical job, including heavy workload, static posture, frequent negative postures of bending and twisting, carrying heavy objects, pulling, pushing, hauling, and repetitive works, is influential in the occurrence of musculoskeletal pain[3-5]. Especially in the event of repetitive work, workers' pain in their shoulders, necks, and upper limbs are more likely to occur[6,7]. The pain symptoms present during the working period of 6-12 months[8]. Since medium and heavy loading works require workers to maintain a constant posture and a limited scope of movement of the limbs in order to maintain a certain production rate, muscles are constantly in such a position that fatigue of muscles and pain often result in discomfort in portions of their shoulders, backs, butts and knees.

Many studies have revealed that those blue-collar workers involved in medium and heavy

loading works are more likely to be prone to have muscular pain in a clinical diagnosis than white-collar workers[9]. Schreuder KJ's research found that a blue-collar worker's lower back pain is more significant than that of white-collar employees. This finding is because the former are more often exposed to body work loading, lifting and hauling heavy objects, and poor posture from long-term bending[10]. Jansen JP's research, which involved 769 nursing employees of the nursing house, calculated the weekly working hours in postures of 20° and 45° body bending and the accumulative physical loading exposure of lifting or moving loads over 10 kg. The dose-response effect occurs between the body loads of the body's trunk bending more than 45° and lifting loads over 10 kg, causing lower body pain, when including lower body pain symptoms in a linear statistical model analysis[11]. Employment-related discomfort and occupational health risk factors are also identified.

Fatigue results from overworking and often involves a unique illness-sensed physical hypoactivity. Fatigue can be either mental or physical. The former is often caused by a person's lack of motivation, emotion, interest, and habits whereas the latter refers to work-related fatigue as a result of energy overload. Causes of fatigue include work scope (active/static muscular loading, hyper intensity, and dullness of work), work environment (lightning, temperature, activity area, artificial engineering), work system (constrained work time, continuous working and planning of rest time), life conditions (constrained or half-constrained time that affect the time spent on hobbies), and adaptation

ability to work (personal age and physical condition) [12]. According to the Institute’s 2004 research on occupational environment safety and health acknowledgement, the fatigue index of workers in the manufacturing industry was 42.7%[13], which was highest among all the examined industries[14]. Said research also found that when “work loading” is higher, fatigue index is higher. Body work loading is a dangerous risk factor in formation of musculoskeletal discomfort. Wan-yu Yeh has conducted research on occupational fatigue for 36 companies in Taipei City and found that working time and intensity and density of work loading are sources of fatigue. Such findings are especially clear regarding the blue-collar working class (men in particular)[15]. Song YK’s research has shown that white-collar workers are mostly stressed with their intelligence and mental tasks while blue-collar workers experience fatigue through their physical condition[16].

Research on musculoskeletal discomfort has been conducted for such industries as car manufacturing, food and restaurants, semi-conductor, electronic panel, healthcare, hotel, and hotel cleaning services[17]. However, such discussions in the paper and paper manufacturing industry are rare. Research that has focused on types of labor, high-frequency repetitive actions, and white-collar office work is even rarer. Therefore, in this study, workers of pulp and paper manufacturing facility operations are the subject of research where the types of labor, the causes of fatigue for the blue-collar working class and for the white-collar office class, and the body parts with musculoskeletal discomfort are discussed.

Research Methodology

1. Study sample

The manufacturing process for paper products includes converting logs into pulp and other raw materials, re-modulation, pressing, drying, gluing, paper coiling, cutting, and packaging. This study purposively samples a paper products manufacturing factory of a cross-national enterprise in northern Taiwan. The study surveyed a total of 130 individuals with a return of 100 effective samples. The subjects are classified into three types (as shown in Fig.2 and Fig.3)

Class	Type	Scope of work
Blue-collar	laborious	operation of pulp and paper manufacturing equipment and facilities; hauling of heavy loads of pulp and paper products
	repetitive	cooperating with production line to cut, fold, package, and tie the paper products
White-collar	office	Office administration and computer operation

2. Instruments

Labor fatigue is investigated using a structural occupational fatigue survey that includes items of level of fatigue, time of continued fatigue, shifts with fatigue, working days with extreme self-aware fatigue and no self-aware fatigue, and the causes and symptoms of fatigue.

Investigations of musculoskeletal discomfort are based on the Northern Europe Musculoskeletal Questionnaires (“NMQ”) and its credibility has been confirmed by related research[18-20]. The NMQ is herein used for work-related musculoskeletal discomfort on necks, shoulders, upper backs, wrists/arms, lower backs/butts, thighs, knees, calves, ankles, and feet.

3. Statistics

Data processing and statistics are carried out using SPSS 17.0 packaged software for data analysis. Employees' basic information and the fatigue and its causes for different work type are shown by descriptive statistics. One-way ANOVA is employed for population statistical variance of the three work types and the chi-square test is employed to analyze whether there is significant difference in the prevalence of self-aware fatigue in different work types; the statistical significant standard α is set as 0.05.

Results

1. Basic information of employees in different work types in the paper industry

The analytical results of basic information of the subjects in this research showed 64 men and 36 women, with an average age of 47.4 years. As for the distribution of employees in the three work types, 40 have a laborious job (accounting for 40%), 50 have a repetitive job (accounting for 50%), and 10 have an office job (accounting for 10%). Gender, age, and work experience are of no significant correlation among the subjects. 57% of the total subjects do not have constant habits of

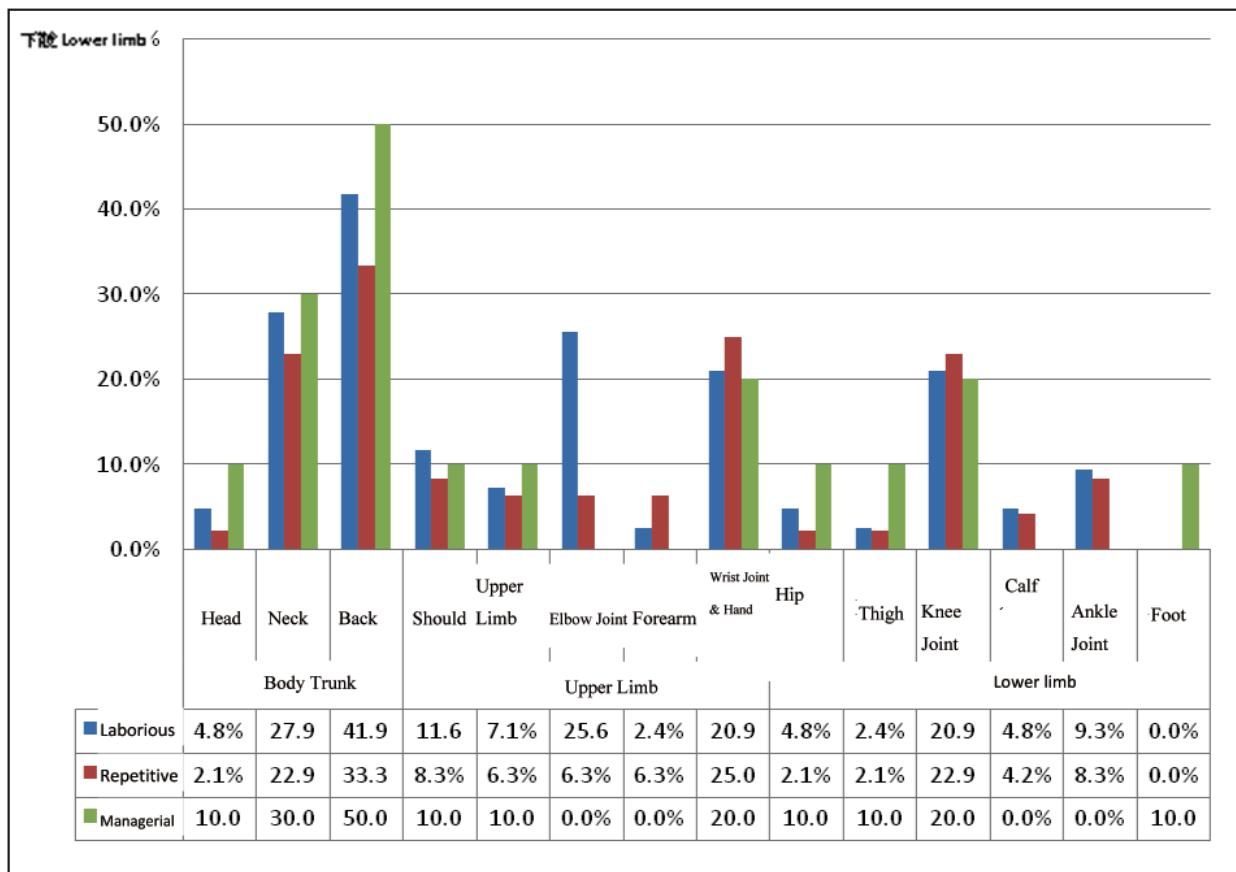


Fig. 1 Body parts where musculoskeletal discomfort occurs for employees of different work types in the paper industry



Fig. 2 Laborious types of work in the paper industry where workers move heavy objects of paper and paper products.

Fig. 3 Repetitive type of work in the paper industry where workers cut and package paper products.

exercise whereas the other 43% do.

2. Prevalence of body parts where employees' musculoskeletal discomfort occurs for different work types of in the paper industry

The body part where musculoskeletal discomfort occurs most often is the body's trunk for employees of all three types of work, and

particularly the discomfort occurs in the neck and back (laborious type: 27.9% vs 41.9%; repetitive type: 22.9% vs 33.3%; office type: 30% vs 50%). Specifically, as shown in Fig. 1, discomfort in the elbows occurs more significantly for laborious-type employees than for repetitive-type employees while discomfort in the wrists and hands occurs more significantly for the repetitive type than for the laborious type.

3. Prevalence of employees' self-aware fatigue for different work types in the paper industry

As shown in Tab. 1, the self-aware level of fatigue and the three different types of work are significantly and statistically correlated. Those who undertake laborious and repetitive types of work are usually or always prone to feeling fatigued. On the other hand, time of continuous fatigue and shift, do not exhibit a significant statistic correlation among all three types of work. It is found that employees of laborious and repetitive types experience continuous fatigue for around 2-3 days and for longer than six months, contributing to a U curve distribution, while that duration for office-type employees is mostly within the section from 1 to 6 months. Fatigue that lasts for more than 6 months mostly occurs in blue-collar and repetitive employees. The greatest fatigue occurs, though, in the late night shift 11PM-7AM (accounting for 79.5%). Of the five weekdays, the day when either mental or physical fatigue reaches its peak is the first day of the week (physical: 52.8%, mental: 46.0%). The fifth day of the week is the day when fatigue is rarely sensed (physical: 34.4%, mental: 57.3%), As shown in Fig. 4 and Fig. 5.

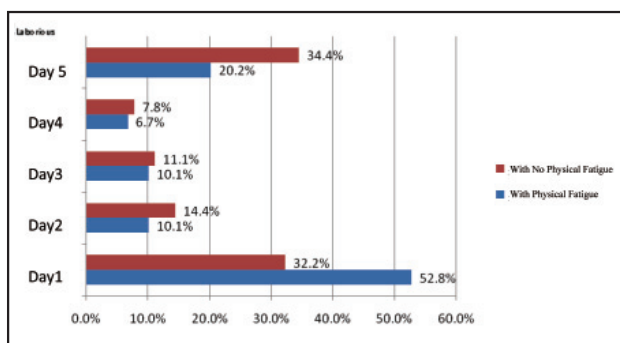


Fig. 4 The working days with extreme physical fatigue and with no physical fatigue

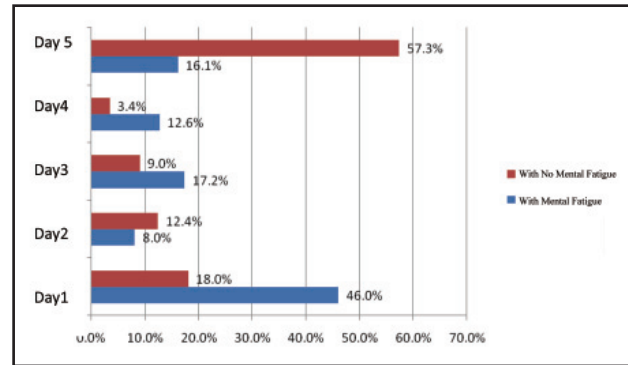


Fig. 5 The working days with extreme mental fatigue and with no mental fatigue

Table 1 Prevalence of employees' self-aware fatigue for different work types in the paper industry

Item Type	Type			Total	p value
	Laborious (n=40)	Repetitive (n=50)	Office (n=10)		
Level of fatigue					0.004
always	2	0	0	2	
	5.0%	0.0%	0.0%	2.1%	
often	5	5	0	10	
	12.5%	10.9%	0.0%	10.4%	
occasionally	18	38	9	65	
	45.0%	82.6%	90.0%	67.7%	
not much	13	1	1	15	
	32.5%	2.2%	10.0%	15.6%	
no	2	2	0	4	
	5.0%	4.3%	0.0%	4.2%	
Duration of continuous fatigue					0.084
2 to 3 days	10	12	1	23	
	31.3%	26.7%	11.1%	26.7%	
within 1 week	4	6	1	11	
	12.5%	13.3%	11.1%	12.8%	
within a month	0	5	1	6	
	0.0%	11.1%	11.1%	7.0%	
more than 1 month but less than 4 months	2	2	3	7	
	6.3%	4.4%	33.3%	8.1%	
more than 3 months but less than 6 months	2	4	2	8	
	6.3%	8.9%	22.2%	9.3%	
more than 6 months	14	16	1	31	
	43.8%	35.6%	11.1%	36.0%	
Fatigue shift					0.062
day shift (7AM-3PM)	5	5	2	12	
	14.7%	14.3%	50.0%	16.4%	
afternoon shift (3PM-11PM)	1	1	1	3	
	2.9%	2.9%	25.0%	4.1%	
night shift (11PM-7AM)	28	29	1	58	
	82.4%	82.9%	25.0%	79.5%	

The causes of paper industry employees' self-aware fatigue include lack of sleep (54%), shifting of work (34%), and high indoor temperatures (31%). Due to different types of work, the workloads of office type employees include significantly heavier workload, intense work stress, and overstress from thinking, and the employees of repetitive work account for a higher percentage of muscle fatigue and even partially for symptoms of muscle weakness. Laborious and repetitive type employees often need to take shifts and they consider the shifts the causes leading to fatigue. Laborious and repetitive type employees spend most of their time on-site at the production line. Those stationed on-site feel that the noise and indoor temperature are the key sources of fatigue, As shown in Tab. 2.

Discussions

The results of this study on musculoskeletal discomfort and laborious fatigue of employees of three types of work in the paper industry have found that for blue-collar, repetitive, and office employees, necks, wrists, hand and backs are the body parts where musculoskeletal discomfort seriously occurs. Due to the nature of daily work in the paper industry where paper is made from pulping and pulp modulating and various kinds of paper are packaged and tied by a half-machine/half-manned manner, the repetitive actions and postures particularly of the upper limbs (mainly hand/wrists) are excessively and extremely required, explaining why the body parts where musculoskeletal discomfort prevails are body trunks and upper limbs.

Table 2 Self-aware fatigue causes of employees of different scopes of work in the paper manufacturing industry

Cause	Type	Laborious	Repetitive	Office	Total
		(n=40)	(n=50)	(n=10)	(n=100)
Workload	heavy workload	7 10.0%	7 14.0%	3 30.0%	17 17.0%
	stress and nervousness	12 30.0%	14 28.0%	3 30.0%	29 29.0%
	laborious work	2 5.0%	2 4.0%	0 0.0%	4 4.0%
	excessive exercise of intelligence	0 0.0%	0 0.0%	3 30.0%	3 3.0%
Capability adapting to work	lack of energy	0 0.0%	0 0.0%	2 20.0%	2 2.0%
	weariness of muscles	0 0.0%	12 24.0%	1 10.0%	13 13.0%
	muscle weakness	0 0.0%	5 10.0%	0 0.0%	5 5.0%
Recovery	insufficiency of sleep	17 42.5%	31 62.0%	6 60.0%	54 54.0%
	lack of proper rest	6 15.0%	6 12.0%	2 20.0%	14 14.0%
	personal life pressure	8 20.0%	5 10.0%	0 0.0%	13 13.0%
Work system and mode	shifts	17 42.5%	16 32.0%	1 10.0%	34 34.0%
	repetitive action of operation	0 0.0%	5 10.0%	0 0.0%	5 5.0%
Environmental factors	loud noises	13 32.5%	12 24.0%	0 0.0%	25 25.0%
	poor ventilation	5 12.5%	2 4.0%	0 0.0%	7 7.0%
	high indoor temperatures	15 37.5%	15 30.0%	1 10.0%	31 31.0%

Little research has focused on the discussions of the differences between the health of blue-collar and white-collar workers and workloads and the discomfort in necks and shoulders in the past. An investigation by Blader et al. demonstrated that 131 employees out of 155 in four mills reported to suffer pain in their shoulders and necks. Evaluating the relations between repetitive actions of arms

and shoulders and musculoskeletal discomfort for workers in font manufacturing, gaffers, film rolling workers, teachers, and office employees[21], Onishi N et al. showed that workers who undertake works frequently with repetitive actions in the upper limbs are 3.8 times more likely to experience discomfort in their necks and shoulders than office employees. Because repetitive actions of the arms and shoulders exercise 10%-30% of the maximum voluntary contraction of the Trapezius muscle in the neck and shoulder, the loading on the neck and shoulder is increased, as is the accumulative muscular fatigue, which in turn leads to pre-symptoms of the local pressing of chronic musculoskeletal discomfort and inflammation[22].

Ohisson K et al. showed that, for female workers in the manufacturing industry divided into a group of repetitive actions with 82 individuals and another group of non-repetitive actions with 64 individuals, multivariate statistics model analysis found that the experiment group with repetitive work exposure risks 3.6 times likelihood to suffer discomfort in their necks than the control group with no such exposure[7]. Furthermore, Burt S indicated that neck and shoulder discomfort often occurs in office employees due to staring at the computer screen when typing, a constantly static posture of the neck, and sitting in a chair without armrests so that arms are often hanging[23]. Many studies in epidemiology also found that repetitive types of work not only affect the movements of necks, but also involve hands and arms. In the event where over exercise and the repetitive overuse of hands exceed the capability of the repairing mechanism, tendon and muscle injuries can result.

Roelen CA indicated that for workers of intensive handicrafts, fast-speed and acceleration of the work flow can result in the significant inflammation of tendons[24].

Previous references have shown that factors such as laborious works, lifting overweight objects, bending and twisting actions, entire body shaking, and static working postures are related to the occurrence of lower back pain. Marras WS indicated that when a man is undertaking overweight loadings such as the manual movement of objects, in order for his body to offset the torque, an unnatural posture results. Furthermore, in the event of overuse of trunk muscles, ligaments, and joints, the forces of pressing and twisting can result in excessive injuries to spinal discs and peripheral muscles tissues[25]. Sweden has conducted surveys on over 209 white-collar and 241 blue-collar workers in eight companies for investigation of the relations between musculoskeletal symptoms and mental and physical workloads and found that in metal manufacturing factories, blue-collar workers are 1.8 times more likely than white-collar workers to have lower back injuries. When exploring the workload factors of blue-collar and white-collar workers, extremely twisted postures were found to frequently occur in blue-collar workers while white-collar workers often work in a static environment[26]. From a Swedish national survey, the relative risk of lower back pain was shown to increase 1.3 times when exercising forward bending, 1.2 times when exercising lifting, and 1.3 times when exercising long periods of standing. From the study herein for employees in the paper industry, where lifting, pushing and moving papers or cardboard boxes

are often required, the back is the body part where musculoskeletal discomfort occurs most seriously for both blue and white-collar workers.

The results of the study were subject to statistics of one-way ANOVA and the self-aware level of fatigue in the three different types of work was found to be of statistical significance ($p < 0.05$), whereas the continuous duration of fatigue and shifting were not. Particularly, those blue-collar workers in a laborious type of work have self-aware fatigue always or often higher than those in a repetitive type of work (accounting for 10.9%). The fatigue durations are mostly short-term, like 2-3 days, and long-term, like six months or more, being distributed as a U curve, while blue-collar workers experiencing chronic fatigue that lasts for more than six months account for the majority. Melamed et al. found that the chronic fatigue experienced by the blue-collar class[27] is more significant than that by the white-collar class, and such finding corresponds to the study herein.

Late night shifts (11PM-7AM) are the shifts where most employees feel fatigue. The cycling regulation mechanism of the human body's physical functionality is mostly controlled in the pineal gland of the brain. Pineal gland stimulates the brain during the day and rests the brain at night in response to periods of light. Workers of the night shift need to counter the physical reaction of sleepiness in order to maintain awake while working. While in time they can sleep, the physical activation due to days makes them more awake such that their sleep deepness is affected, and thus they experience an insufficiency of sleep[28].

According to the investigation of this study,

workload, nervousness, and insufficiency of sleep are the main sources of fatigue as reported by workers in all three types of work examined. However, the differences in the type of work contribute to factorial variations in the causes of fatigue. For example, chemical materials, glues, and pastes used to make paper, the dirty air, noise of machine operation, high temperature and stiffness for lack of air-conditioning, shifting, environmental noises, and high indoor temperatures are the more significant causes of fatigue for blue-collar workers. White-collar office employees mostly work in sales and marketing. Heavy workload, stress, and workload that requires excessive exercise of intelligence are the causes for white-collar employees' fatigue, which corresponds with Roelon CA's finding that white-collar workers engage more in tasks with mental requirement whereas blue-collar workers engage more in heavy-loading works[24]. According to this study, both blue-collar and white-collar workers find the first day of the week to be the day when fatigue reaches its peak, revealing that during the weekday, labor workers are tenser mentally and are only able to rest on their days off. When the holidays end and they need to return to work, they more or less experience post-holiday syndromes, such as fatigue, drowsiness, lack of sleep, and difficulty concentrating, so the feeling of fatigue reaches its peak on the first day of work.

Conclusion

This study proves the differences in causes of fatigue to musculoskeletal disease among three different work types in the paper industry. Blue-

collar workers are exposed more to heavy labor, lifting, and repetitive body loading, as well as loud noises and high temperatures. Musculoskeletal injuries and chronic fatigue are more likely to occur. On the other hand, white-collar workers suffer more mental stress. Insufficiency of sleep and rest occurs more universally in white-collar workers. However, limited by time and human taskforce, the scope of this study is only limited to one factory. It is suggested that the number of factories and number of surveyed individuals should be continuously increased in order to improve the understanding of risk factors of employees' musculoskeletal injuries from exploration of differences of health risks between laborious and repetitive types of work. Health education and the promotion of causes of musculoskeletal injuries and of maintaining good posture during work should be provided to employees, and exercise programs such as stretches, fitness exercises, and aerobics should be introduced to employees in order to improve workers' required muscular strength, persistence and mobility of joints. Providing employees with a safe and healthy working environment would decrease the frequency of musculoskeletal injuries and further increase productivity.

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