Musculoskeletal disorders, foot health and footwear choice in occupations involving prolonged standing.

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Abstract

Occupations that involve prolonged periods of standing and maintaining an upright posture are associated with an increased risk of work-related musculoskeletal disorders (WMSD), particularly of the lower back and lower extremities. Identifying factors that impact WMSD is therefore important, but the foot and footwear have been largely ignored to date. Therefore, this study aimed to assess the prevalence of WMSD of the lower back and lower extremity with emphasis on foot health and the impact of footwear. A cross-sectional questionnaire was completed by 147 surgical workers who were standing for long periods in their working day. It assessed job demands, individual characteristics, WMSD prevalence, psychosocial factors and footwear, with a multivariate analysis to identify relationships between variables. Results found the low back was the most predominant area of WMSD (71%), but the foot had the second highest prevalence (55%). The plantar foot surface was the main region of foot pain with everyone that experienced foot pain reporting it under the heel, ball of foot or arch region. Footwear was recognised as an influencing factor on WMSD by the participants as well as by the multivariate analysis, highlighting the importance of exploring footwear to reduce WMSD. Footwear comfort, footwear fit, footwear choice and the provision of footwear by employers were all identified as important factors to consider in relation to WMSD and foot health.

Relevance to Industry

Footwear is related to WMSD which are seen in the majority of workers undertaking prolonged standing. Employers of these workers and footwear suppliers should consider footwear comfort, particularly its fit and individual preference for footwear characteristics including underfoot cushioning and support. This should also include consideration of the range of footwear available and how it is selected by workers.

Keywords: Prolonged standing; footwear; shoe; musculoskeletal disorder; questionnaire; surgeon; nurse

Introduction

Occupations that involve long periods of standing and maintaining an upright posture are associated with an increased risk of work-related musculoskeletal disorders (WMSD), particularly of the lower back and lower extremity (Andersen et al., 2007; Coenen et al., 2016). Working in operating theatres requires periods of prolonged static standing in a challenging, stressful and complex work environment (Sheikhzadeh et al., 2009). This is reflected in the high number of WMSD reported in those working in operating theatres. Indeed, 73% of surgeons report suffering from a WMSD at some point in their career (Meijsen and Knibbe, 2007) and in a cohort of perioperative workers, 84% reported low back pain, 58% pain in the knee and 74% foot/ankle pain (Sheikhzadeh et al., 2009). Similarly, around 60% of theatre nurses reported pain in each of these regions over 12 months (Choobineh et al., 2010).

Due to the high proportion of workers suffering from WMSD, recognising factors that can impact the risk of WMSD is imperative for identifying solutions. Physical factors have been identified as the most salient risk factor by both surgical practitioners themselves as well as in a regression analysis looking at risk factors for WMSD (Szeto et al., 2009). Prolonged periods standing in a single posture, continuing to work when in pain and moving or carrying heavy objects were strongly linked to WMSD in surgeons (Szeto et al., 2009). Other factors include age, gender, BMI and psychosocial elements (Choobineh et al., 2010; Dianat et al., 2018). Physical exercise outside of work has been suggested as a risk factor due to the further stress it places on the musculoskeletal system (Punnett and Wegman, 2004).

Despite most individuals reporting foot and/or ankle MSD at work, we have a very limited understanding of causes of, or potential solutions to, this discomfort. Back and leg WMSD are frequently prioritised over foot health, with the foot typically considered in conjunction with the ankle (e.g. pain in the ankle/foot region), thus limiting our understanding of the details of WMSD in these areas (D'Souza et al., 2005). Indeed, it was not possible to find a study considering the feet as a single region in surgical workers (Choobineh et al., 2010; Dianat et al., 2018; Sheikhzadeh et al., 2009).

One potential impacting factor on foot pain is footwear as it provides the interface between the worker and the floor and can impact posture, movement and forces passing through the body (Anderson et al., 2017b). It might therefore influence WMSD in the legs and back as well as the feet (Anderson et al., 2018). Furthermore, standing workers have previously identified the importance of footwear and foot health in being able to work effectively as well as being essential for a good quality of life outside of work (Jennifer Anderson et al., 2017a; Stolt et al., 2017). Thus, improving footwear could be important for reducing WMSD, improving individual quality of life and impacting work factors such as productivity.

Despite the potential importance of footwear, current UK guidelines for workers undertaking prolonged standing do not provide guidance on footwear in relation to musculoskeletal disorders of the lower limbs, although they do recommend anti-fatigue matting (Health and Safety Executive). Research on footwear for prolonged standing workers is minimal but there is evidence that it does relate to musculoskeletal disorders, and that it could potentially provide a greater benefit than anti-fatigue matting (Speed et al., 2018). Work footwear has been shown to alter biomechanical variables such as plantar pressure and muscle activity (Anderson et al., 2017; Chiu and Wang, 2007; Kersting et al., 2005), further suggesting its potential link with musculoskeletal disorders.

As footwear preference varies between prolonged standing workers (Anderson et al., 2020), considering footwear comfort is perhaps more important than the physical and mechanical description of the shoe. This is reinforced by research that has found subjective ratings of footwear to be more strongly related to injury risk than the physical properties of footwear and insoles (Grier et al., 2011; Mündermann et al., 2001). Additional footwear factors, such as the use of insoles/ orthotics and how often footwear is replaced have also been linked to injury risk (Grier et al., 2011). Therefore, including footwear factors in epidemiological multivariate analyses is important in understanding factors that could influence WMSD.

With previous limitations in mind, this study aims to assess the prevalence of lower back and lower extremity WMSD in prolonged standing workers with respect to multiple risk factors, including a focus on the impact of standing on foot health and the effect of footwear.

Method

Ethical approval was gained from the University (HSCR 13-152), alongside approval from the National Health Service (NHS) Health Research Authority (IRAS project ID: 192183).

Study Design

The questionnaire was designed to focus on 5 key areas: job information, individual characteristics, musculoskeletal disorders at work, psychosocial factors and footwear. It contained multiple choice (MC) and free text (FT) questions. These were developed by a combination of previous work (Alexopoulos et al., 2004; Andersen et al., 2007; Sheikhzadeh et al., 2009; Sterud and Tynes, 2013), a pilot questionnaire (N=47) to develop the footwear related questions (n=47), particularly the answers/ wording of MC questions (e.g. insole features, work sites, footwear type) and free text questions were used when it was deemed limiting or guiding to use a MC style question (e.g. anything that exacerbates pain, how footwear comfort could be improved).

Job information included job title (FT), years in job (MC), hours per week (MC), percentage time spent on feet, sitting, standing and walking while at work (MC – 10%,20%...100%). Individual characteristics were self-reported and included age (MC), height (FT) and weight (FT) from which BMI were calculated.

Musculoskeletal disorders were assessed using a modified version of the Nordic questionnaire for the analysis of musculoskeletal pain (Kuorinka et al., 1987). Body regions were defined as seen in the questionnaire, although the foot and ankle were presented as two separate options (i.e. low back, hip/thigh, knee, lower leg/calf, ankle, and foot). The following were assessed for each area (MC): pain over the last 12 months, pain over the last 7 days, if it affected their work, if professional help had been sought and if they had taken any time off work as a result. One question asked individuals to select a word that best described their pain from the McGill pain short form questionnaire list (Melzack, 1987). For each region, they noted down anything they believed exacerbated their pain (FT), afflicting conditions that could influence pain (FT), any foot conditions (FT) and if these conditions were diagnosed by a professional (MC). The foot was separated into nine regions and respondents were asked to select all regions in which they felt pain (MC). The regions were: inside of big toe, top of toes, back of heel, bottom of heel, under arch area, outside edge of foot, ball of foot, underside of toes and between toes.

Psychosocial questions were taken from the Short Form Copenhagen Psychosocial Questionnaire (Kristensen et al., 2005; NRCWE, 2005), as it is commonly used in work environments (Bernal et al., 2015). Previous research, including a meta-analysis, examined the contributing psychosocial factors to WMSD, thus to avoid the addition of over 40 questions, which could reduce response rate, only the 13 questions identified to have a known association with work MSD were included (Andersen et al., 2007; Bernal et al., 2015; Gell et al., 2011). These covered the topics of job control, rewards/recognition, social support, demands and job satisfaction.

Footwear questions developed by the researchers asked individuals to select what type of footwear they wore (MC), where the shoes were purchased from (MC), if they rotated between multiple pairs of shoes (MC), if they wore socks (MC), if they used insoles/ orthotics (MC), and the features of these insoles/ orthotics (MC/FT). Current footwear comfort was assessed on a scale of 1-10 (1=worst comfort imaginable, 10 = most comfortable shoe imaginable) and they were asked to define what comfortable footwear meant to them (FT). Questions also asked them to describe how their footwear could be improved (FT).

The full questionnaire was sent for pilot testing to 3 healthcare workers. They were instructed to fill the questionnaire online and make notes of any questions that they did not

completely understand (relating to the questions, instructions for filling it out, time taken to complete and its layout). Changes were made accordingly and included changing the time on feet/walking/standing to percentage multiple choice responses and rewording the introduction. It was reported to take about 10 minutes to complete.

Study Population/ Recruitment

All respondents were operating theatre practitioners in NHS hospitals in England. Research departments at randomly selected hospitals were approached and those that agreed to take part (n=9) distributed a link to the online questionnaire via email to surgical practitioners between March 2016 and August 2017. This covered a total of approximately 160 operating rooms. This email was sent out twice, at least a week apart to increase participation.

Data Analysis

Simple FT questions were numerically coded for statistical analysis with the most common responses given a numerical code and individual answers classed as 'other' (job title, work site, footwear type). FT questions such as 'tasks and movements associated with discomfort' and 'how current footwear could be improved' were counted based on all factors that were mentioned and ranked in order from those most frequently mentioned to those least frequently mentioned. The modified Nordic Musculoskeletal Questions were simple yes/no questions that were scored using binary coding. Psychosocial scores were calculated as previously (NRCWE, 2005), to derive a score for quantitative demands, emotional demands, workplace tempo, social support, rewards/recognition and job satisfaction.

Statistics

Univariate analysis was conducted using χ^2 and independent t-tests for categorical and continuous variables, respectively, for each individual body region. Variables with a p value of less than 0.25 were included in the multivariate analysis, as previously suggested (Choobineh et al., 2010). All plausible interactions between factors were tested and if interactions were found, only the variable that had the greatest impact on the final model was included in the analysis (Table 5). Those with p values below 0.25 were included in the multivariate analysis. Where two variables are correlated, and both have a p value below 0.25, only the variable with the lowest p value was included in the multivariate analysis. Gender and age were included in the model for every region as these were considered important confounders (Alexopoulos et al., 2004; Gell et al., 2011). Multivariate analysis was conducted using backward stepwise logistic regression (Wald) to create one model for each region (low back,

hip/thigh, knee, ankle and foot). Variables with a p value below 0.1 were included in the final model. All statistical analysis was completed in SPSS (v23).

Results

The questionnaire was completed by 152 respondents. Although the exact response rate is not known, it is estimated to be at around 10% (average of 9-10 practitioners per operating room from 160 operating rooms). Responses were removed if individuals main work site was selected as an office (n=5), leaving 147 whose main work place was the operating theatre in the final analysis. This is similar to a previous study assessing WMSD in surgeons using a modified Nordic questionnaire that had 135 responses (Szeto et al., 2009).

Table 1: Participant demographics. Nurse includes all nurses, head nurses and sisters. Theatre assistants includes operating department practitioners and theatre support workers. Specialist roles includes surgeons, anaesthetists, recovery.

		Female	**Male**
		Mean (STD)	**Mean (STD)**
	Gender	112	35
	Height (m)	1.63 (0.09)	1.76 (0.10)
	Weight (kg)	70.4 (14.7)	83.7 (14.5)
	BMI (kg/m^2)	26.0 (6.2)	27.1 (3.5)
		Total (%)	**Total (%)**
Age (years)	**<40**	28 (25.0)	12 (34.3)
	40-50	41 (36.6)	12 (34.3)
	>50	43 (38.4)	11 (31.4)
Hours/week	**<40**	88 (78.6)	15 (42.9)
	>40	23 (20.5)	20 (57.1)
Time in job	**0-10 years**	31 (27.9)	11 (31.4)
	11-20 years	37 (33.3)	12 (34.3)
	21-30 years	21 (18.9)	10 (28.6)
	30+ years	22 (19.8)	2 (5.7)
Occupation	**Nurse**	56 (50.0)	3 (8.6)
	Theatre Assistants	36 (32.1)	13 (37.1)
	Specialist Roles	20 (17.9)	19 (54.3)

Most respondents were female (76%), with the demographics displayed (Table 1). The average self-reported time on the feet was 73±22% of work time, standing was 53±29% of work time, walking was 48 ± 29% of work time and sitting 22±17%.

Musculoskeletal discomfort

MSD were reported by 91% of respondents in at least 1 region in the last 12 months and 68% in the last 7 days (Table 2). The lower back was the most frequent region affected with 71% reporting pain in the last 12 months. In the feet, 55% reported pain over the last 12 months with the area under the medial arch, ball of the feet and heel the most common areas (Table 3).

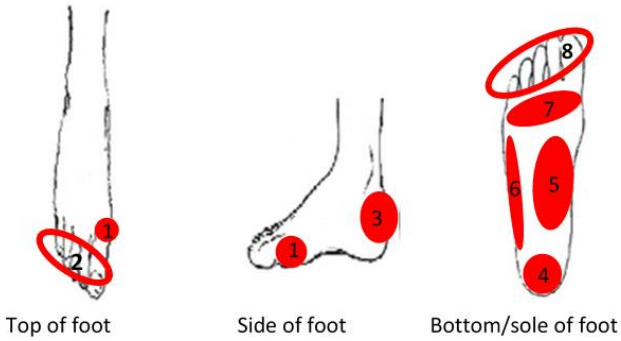
Table 2: Number of respondents reporting MSD and if it resulted in work problems and professional help being sought.

Region	Last 12 months	Last 7 days	Prevent normal work	Time off work	Professional help sought	Factors attributed to Pain *
	Total (%)**					
Low back	104 (70.7)	54 (36.7)	31 (21.1)	12 (8.2)	23 (15.6)	Standing, bending/ twisting, lifting/ pushing, lead aprons
Hip/thigh	61 (41.5)	40 (27.2)	17 (11.6)	7 (4.8)	19 (12.9)	Standing, walking, bending/twisting, lifting/pushing
Knee	58 (39.5)	36 (24.5)	17 (11.6)	8 (5.4)	18 (12.2)	Standing, walking, bending/twisting, kneeling, lifting/pushing
Calf	41 (27.9)	24 (16.3)	6 (4.1)	4 (2.7)	13 (8.8)	Standing, walking, lifting/ pushing
Ankle	24 (16.3)	16 (10.9)	7 (4.8)	3 (2.0)	9 (6.1)	Standing, walking, lifting/ pushing
Foot	81 (55.1)	53 (36.1)	9 (6.1)	2 (1.4)	15 (10.2)	Standing, walking, footwear
Any region	134 (91.2)	100 (68)	51 (34.7)	25 (17.0)	51 (34.7)	-

* Factors attributed to pain are in order of how frequently they were mentioned – the most frequently mentioned is listed first. **Percentages are of entire population.

Overall, 35% of respondents reported seeking professional help for their pain at some point, with 35% prevented from completing their normal work and 17% forced to take time off work. A total of 20 respondents (14%) reported suffering from a known medical condition that could exacerbate pain (5% osteoarthritis, 0.7% rheumatoid arthritis and the remaining reporting various conditions including diabetes, fibromyalgia and psoriatic arthritis).

Table 3: Foot pain regions for entire population. Percentages are of total population.



Regions	% Total population
1 – inside of big toe	17%
2 – top of toes	15%
3 – back of heel	12%
4 – bottom of heel	35%
5 – under arch area	47%
6 – outside edge of foot	21%
7 – Ball of foot	52%
8 – Underside of toes	10%
9 – Between toes	5%

Pain in any region was most commonly attributed by the respondents to standing (Table 2) with walking identified as a contributor for MSD in all regions. In the low back, hip and knee, bending/ twisting and lifting/ pushing were also identified as attributors. Lifting/ pushing movements were related to pain in the calf/ ankle. Footwear was recognised as a contributing factor to pain only in the feet. The pain was most commonly described as an ‘aching’ pain (46%), with ‘throbbing’ (14%) the second most common word to describe pain. In the foot, 35% described the pain as ‘aching’, 16% described it as ‘throbbing’, and 15% described it as ‘hot-burning’.

Known foot conditions were reported by 36% of participants. The most common condition was plantar fasciitis (8.2%). The remaining were: low arch (6%), bunions (4.8%), corns (3.4%), high arch (2.7%), blisters (2.0%), calluses (2.0%), fungal condition (2.0%), tendonitis (1.4%), hammer toe (0.7%) and gout (0.7%). Of these individuals, 30 (57%) stated they were diagnosed by a professional.

Workplace footwear

There were 4 main footwear types worn by operating theatre practitioners (Table 4). Washable clog (normally made entirely from EVA but sometimes from TPU/TPR), standard

clog (usually leather/microfibre upper), trainer, dress shoe/ flat and any further types were classified as other – this included wellington boots and orthopaedic sandals. Additional insoles were used by 15% of the population, with 76.2% of those wearing insoles with arch support, 22.7% heel raise, 18.2% cushioning, 18.2% lateral wedge and 4.5% shock absorption. The majority (73%) had only one pair of footwear that was worn every day and socks were worn by 90% of the population. Footwear was most frequently purchased from a work shoe store (48.3%), but over a third purchased footwear from a high street shoe store and 8% purchased from a high street clothing store (Table 5). Footwear purchased from a work specialist company had an average comfort rating of 5.8±2.4 compared to that not purchased at a work specialist store that had an average comfort rating of 7.4± 2.6.

Table 4: Examples of commonly worn footwear

Washable Clog	**Standard Clog**	**Trainer**	**Dress Shoe/Flat**
			
Often made entirely from EVA with slip resistant sole	EVA/PU sole with leather upper	Foam sole with material upper.	Flat shoe with thin sole and leather/ microfibre upper

When asked what ‘comfort’ meant to them, 50% (of the 84% who responded) suggested comfort related to no pain or discomfort, with 37% specifying this comfort must continue for a prolonged period and 11% suggesting it meant they were unaware of footwear during the working day. In terms of footwear characteristics, the following were suggested as important: cushioning (26%), support (23%), breathable/ heat minimising (10%) and lightweight (3%). Current footwear comfort was scored on average at 6.6±2.2 out of 10. When asked how their footwear could be improved, 41% suggested it could not be improved or did not answer. Of those that did answer, 36% suggested footwear needed more cushioning, 23% suggested the fit was not correct, 15% suggested the shoe could be more supportive. However, 24% stated that the shoes provided by employers were not adequate, 7% cited poor quality and 9% that there was not enough choice and that one shoe does not suit everyone. As a result of this, some reported purchasing their own shoes.

Table 5: Information regarding current footwear use and comfort.

		Washable Clog	Standard Clog	Trainer	Dress Shoe/flat	Other **	All shoes	Total
		Number of Respondents						*%*
	Total	50	27	31	22	17	147	100
Where shoe purchased	**Supermarket**	1	0	0	0	0	1	0.7
	High street clothing store	2	0	4	6	0	12	8.2
	High street shoe store	9	5	19	16	5	54	36.7
	Work shoe store	38	22	6	0	5	71	48.3
Insole use	**No**	47	27	20	18	14	126	85.7
	Yes	3	0	11	4	3	21	14.3
	Prescribed	2	0	5	2	1	10	6.8
Pairs of shoes	**1 pair**	38	22	24	16	8	108	73.5
	More than 1 pair	12	5	7	6	9	39	26.5
Current footwear comfort *	**Mean**	5.4	6.4	7.6	7.7	7.4	6.6	-
	Standard Deviation	2.4	2.7	2.1	2.3	2.0	2.6	-

*Footwear comfort was assessed on a scale from 1-10, with 1 being the least comfortable footwear imaginable and 10 being the most comfortable footwear imaginable.

**Others specified were wellington boot and orthopaedic/orthotic sandals

Multivariate Analysis

Univariate associations can be seen (Table 6) that were entered into the multivariate analysis if they had a p-value below 0.25 and did not correlate with other variables (where two variables correlated, the one with the greatest association was included in the model). The multivariate analysis found numerous factors contributed to MSD (Table 7-8). Being female increased the risks of suffering from pain in the low back, hip/thigh, calf and foot. There was a significant impact of age only in the knee where those that were aged above 50 were more likely to suffer knee pain (odds ratio: 3.5; 95% CI, 1.2-9.8). Psychosocial factors were also associated with an increased risk of MSD. Namely, job satisfaction, influence at work, emotional demands and rewards/recognition were all included in the model for at least one region. High emotional demands, low rewards and recognition, low job satisfaction and a low influence at work were all detrimental. In relation to footwear, a greater footwear comfort corresponded to a decreased risk of suffering from hip/thigh (odds ratio = 0.9, 95% CI = 0.7-1.0), knee (odds ratio = 0.9, 95% CI = 0.7-0.9) and foot pain (odds ratio = 0.8, 95% CI = 0.7-0.9). A high BMI also increased the risks of suffering from ankle/foot pain and an increase in height was a risk factor for low back pain.

Table 6– P values for t-test/ chi squared tests for univariate analysis.

	Variable	Correlated with:	Univariate analysis results (p-value)					
			Low Back	Hip/ Thigh	Knee	Calf	Ankle	Foot
a	**Gender**		0.491	**0.026**	0.588	**0.034**	0.573	**0.237**
b	**Age**		**0.072**	0.736	0.414	0.906	0.277	0.842
c	**Height**	*e*	**0.039**	0.563	0.632	**0.221**	0.799	0.585
d	**BMI**	*e*	0.817	0.797	0.276	0.713	**0.009**	**0.013**
e	**Weight**	*d*	**0.119**	0.895	**0.06**	0.505	*0.019*	*0.019*
f	**Exercise per week**		0.255	0.371	0.716	**0.073**	0.387	0.878
g	**Hours per week**		**0.145**	**0.23**	0.99	0.388	0.569	0.461
h	**Time in Job**		0.278	0.409	0.48	0.056	0.67	**0.068**
i	**Time Sitting**	*j,k,l*	0.401	0.57	**0.203**	0.12	**0.013**	*0.032*
j	**Time on Feet**	*i,k,l*	0.624	0.8	0.504	**0.055**	0.465	**0.01**
k	**Time Walking**	*i,j,l*	0.53	0.705	0.474	*0.147*	0.332	0.255
l	**Time Standing**	*i,j,k*	0.621	**0.241**	0.46	0.437	0.648	0.297
m	**Shoe Type**		0.295	0.58	**0.065**	**0.172**	0.661	0.716
n	**Where Shoe was Purchased**		**0.247**	0.998	0.737	**0.042**	0.369	**0.162**
o	**More than 1 pair of shoes**		0.323	0.493	0.844	0.965	0.348	0.876
p	**Insole Use**		0.554	**0.029**	**0.029**	**0.023**	**<0.001**	0.52
q	**Current Shoe Comfort**		0.561	**0.244**	**0.057**	**0.174**	**0.152**	**0.025**
r	**Quantitative demands**	*s,t,x*	0.728	*0.1*	0.909	0.756	**0.122**	0.639
s	**Workplace Tempo**	*r,t*	0.911	**0.095**	0.591	0.933	**0.219**	0.321
t	**Emotional Demands**	*r,s,x*	*0.083*	0.402	0.646	**0.219**	0.405	**0.072**
u	**Influence at Work**	*v,w,x*	*0.164*	0.424	**0.138**	0.463	0.696	*0.029*
v	**Rewards/Recognition**	*u,w,x*	*0.227*	0.468	0.516	0.85	0.842	**0.025**
w	**Social support**	*u,v,x*	0.393	*0.152*	0.582	0.726	0.672	0.882
x	**Job satisfaction**	*r,t,u,v,x*	**0.017**	**0.109**	0.941	0.959	0.757	0.673
y	**Occupation**		0.323	**0.065**	**0.246**	0.93	0.296	**0.048**

Numbers in bold were included in multivariate analysis, *numbers in italics* are those that correlated with another and were therefore not included

Table 7: Multivariate Analysis for each body region. Variables with p<0.1 were retained in the model. CI = 95% confidence intervals.

		Low back		Hip/ thigh		Knee	
		Odds ratio (CI)	*p*	*Odds ratio (CI)*	*p*	*Odds ratio (CI)*	*p*
Gender	**Male**	1.0		1.0		1.0	
	Female	3.4 (1.1-10.6)*	0.036	3.3 (1.1-10.0)*	0.031	0.9 (0.4-2.1)	0.761
Age	**<40**	1.0		1.0		1.0	
	40-50	0.4 (0.1-1.2)	0.140	0.7 (0.2-1.9)	0.441	0.2 (0.9-6.8)	0.076
	>50	0.3 (0.1-1.0)	0.054	0.8(0.3-2.2)	0.683	3.5 (1.2-9.8)*	0.019
	Height (cm)	1.1(1.0-1.1)*	0.016				
Occupation	**Nurse**			1.0			
	Theatre Assistants			3.3 (1.2-8.8)*	0.017		
	Specialist roles			1.5 (0.5-4.6)	0.511		
	Work place tempo			1.3 (1.0-1.8)	0.057		
Psychosocial factors	**Job satisfaction**	0.3(0.1-0.7)*	0.004				
	Influence at work					0.8 (0.7-1.0)	0.094
shoe purchased	**Non-work specialist company**	1.0					
	Work specialist company	2.4 (0.97-6.1)	0.058				
	Current footwear comfort			0.9 (0.7-1.0)	0.057	0.9 (0.7-0.9)*	0.031

* = p<0.05.

Table 8: Multivariate Analysis for each body region. Variables with p<0.1 were retained in the model. CI = 95% confidence intervals.

		Calf		Ankle		Foot		Any pain **	
		Odds ratio (CI)	*p*	*Odds ratio (CI)*	*p*	*Odds ratio (CI)*	*p*	*Odds ratio (CI)*	*p*
Gender	**Male**	1.0		1.0		1.0		1.0	
	Female	3.34 (1.1-10.2)*	0.034	0.6 (0.2-2.0)	0.421	2.6 (1.0-6.5)*	0.044	2.2 (0.6-9.0)	0.256
Age	**<40**	1.0		1.0		1.0		1.0	
	40-50	1.6 (0.5-5.3)	0.172	2.3 (0.5 -10.2)	0.260	0.5 (0.2-1.5)	0.228	0.2 (0.0-2.1)	0.180
	>50	1.4 (0.4-4.8)	0.763	2.0 (0.4-9.0)	0.382	0.6 (0.2-1.9)	0.414	0.1 (0.0-1.4)	0.096
	BMI			1.1 (1.0 -1.2)*	0.02	1.1 (1.0-1.2)*	0.043		
	Exercise/ week	0.8(0.6-0.9)*	0.036						
Hours/week	**<40**							1.0	
	>40							0.2 (0.1-0.8)*	0.027
Psychosocial factors	**Work place tempo**			1.5 (1.0-2.3)	0.066				
	Job satisfaction							0.4 (0.1-1.2)	0.094
	Emotional Demands	1.3 (1.0-1.6)	0.078						
	Rewards/ recognition					0.7 (0.6-0.9)*	0.006		
Shoe purchased	**Non-work specialist**	1.0							
	Work specialist company	1.6 (1.1-6.5)*	0.044						
	Current footwear comfort					0.8 (0.7-0.9)*	0.029		
Insole use	**No**	1.0		1.0					
	Yes	3.6 (1.1-11.7)*	0.032	8.0 (2.2-28.8)*	0.001				

* = p<0.005 **Any pain = pain in one or more of the body regions included

Discussion

In line with previous research, this study found the majority (91%) of surgical workers reported at least one region of WMSD in the previous 12 months of work. Despite earlier research primarily focusing on the lower back and legs, the foot was the second most common region for WMSD, with 55% reporting foot discomfort and 36% reporting a known foot condition. This suggests that reducing foot pain is important for reducing the overall discomfort of these workers, despite being previously overlooked. The multivariate analysis found multiple factors were related to lower body WMSD in this population including individual characteristics, occupational factors and psychosocial factors. Furthermore, footwear was also identified to have an association with WMSD by the participant themselves as well as by the multivariate analysis, highlighting the need to explore footwear as a means to reduce WMSD. The insight into workers views regarding footwear can be used to draw suggestion for both future research and footwear development.

Foot and ankle WMSD have previously been assessed together, with a recorded prevalence of 59-74% (Choobineh et al., 2010; Sheikhzadeh et al., 2009). We identified that the majority of these occur in the feet (55%) rather than the ankle (16%) and therefore future studies should not combine these regions and risk obscuring the high prevalence of foot WMSD. The large number of participants suffering from foot pain is further stressed by a comparison to that in the general population. Over one month, 17-22% of a sample from the general population reported foot MSD (Garrow et al., 2004; Hill et al., 2008). Our 12-month prevalence was 2.8 times greater than this average and our 7-day prevalence about 1.8 times greater.

The main regions of pain in the foot were on the plantar surface, agreeing with that reported in the general population (Garrow et al., 2004). The ball of the foot (52%), arch (47%) and heel (35%) were the most common areas. Pain onset in the heel and ball of foot regions has been shown to coincide with locations of high pressures when standing (Gell et al., 2011). Although pressures under the midfoot region are generally lower than the heel and ball of the foot, sensitivity is significantly greater (Hennig and Sterzing, 2009; Xiong et al., 2013), perhaps explaining why this could also be a region of pain. Constant loading of internal structures, such as the plantar fascia could also be a contributor.

In terms of reducing foot pain, BMI was found to be related to foot WMSD in the multivariate analysis. This combined with the fact that the average BMI of participants was in the overweight category indicates that a reduction in weight would be one mechanism to reduce work related foot discomfort. The relationship between foot WMSD and BMI or weight has been identified in different standing populations, including prospectively (Andersen et al.,

2007; Hill et al., 2008; Irving et al., 2007), with larger BMI thought to be linked to increased plantar load (Birtane and Tuna, 2004; Butterworth et al., 2015; Hills et al., 2001). Structural changes in the foot may also occur as a result of the extra weight, such as the lowering of the medial arch, which could impact function and thus discomfort (Hill et al., 2008; Irving et al., 2007; Mickle et al., 2006).

This paper provides evidence of an association between footwear and lower body WMSD suggesting that a focus on workplace footwear is warranted as a means of reducing the risk of WMSD. Footwear comfort was related to knee and foot pain in the multivariate analysis, concurring with previous research associating greater footwear comfort with a reduction in lower limb injury risk (Kinchington et al., 2011; Mündermann et al., 2001). It has been suggested that this link is the result of a comfortable shoe being one that supports an individuals preferred movements thus resulting in a reduction of injury (Nigg et al., 2015). Footwear comfort in standing workers and runners varies between individuals, with different preferences for underfoot cushioning and contouring specifically (Anderson et al., 2020, 2018; Miller et al., 2000; Mills et al., 2011; Mündermann et al., 2003, 2001). This aligns with the finding in this study that cushioning and support were the most frequently mentioned components of footwear that could be improved. Insufficient footwear choice was also mentioned, thus providing a range of footwear for standing workers to choose from, with appropriately different characteristics, might be beneficial in improving footwear comfort and therefore reducing WMSD.

Surprisingly, wearing a shoe that was purchased from a work specialist company was also associated with WMSD in the low back and calf. Moreover, footwear comfort was almost 30% greater in those not acquiring their footwear from a work shoe specialist compared to those who did. From experience, we know that it is likely that a high proportion of individuals obtaining footwear from a work shoe specialist will do so through their employer rather than by private purchase. This often means that the shoes are not tried on prior to purchase and options for footwear are limited to specific suppliers or styles. Indeed, almost a quarter of individuals who were not happy with their footwear suggested the footwear provided by their employer was not adequate, with poor quality and limited choice cited as reasons. Poor footwear from employers has led to nurses purchasing their own footwear (Stolt et al., 2017), which may prioritise comfort over safety (Norlander et al., 2015). Adjusting the method with which employers provide footwear for their employees could ensure a wider choice of footwear is made available and consider improved methods of footwear selection instead of, or as an adjunct to trying shoes on.

Trying footwear on prior to purchase is also important for ensuring good fit. Of those that reported their current footwear could be improved, almost a quarter suggested the fit wasn't right. The presence of issues with the fit of footwear are supported by the identification of pain at areas such as between the toes, on the back of the heel and on the outer edges of the foot coupled with reports of blisters, corns and calluses. In agreement, nurses have associated ill-fitting footwear with poor foot health (Stolt et al., 2017). It has been suggested that fit is the most critical factor relating to footwear comfort and only when a shoe fits well do other factors relating to comfort such as cushioning and contouring become important (Miller et al., 2000).

In terms of foot conditions recognised by a health professional, the most common condition reported was plantar fasciitis. For workers with plantar fasciitis, rotating footwear during the work week (i.e. having more than one pair of shoes that are worn alternately) has been found to be protective (Werner et al., 2010) and this approach has been suggested for runners too (Malisoux et al., 2015). With 73% of participants in this study owning only a single pair of work footwear, use of footwear rotation for improved foot health at work could be an important avenue of further research.

Thus from these results and the surrounding literature a number of footwear recommendations can be drawn. A comfortable shoe should be worn, considering long term comfort as well as immediate as they can vary (Anderson et al., 2020). Employers and manufacturers should offer a selection of footwear to workers in relation to both fit and comfort, with an emphasis on cushioning and support. If it is not possible to try footwear on, other methods should be used to predict the most comfortable shoe, such as questionnaires that have been shown to improve footwear selection (Anderson et al., 2020). Having more than one pair of shoes and rotating the pair worn could be beneficial for foot pain and plantar fasciitis, the most common foot condition identified. Manufacturers should focus on reducing foot pain on the plantar foot region during long standing or upright periods.

There are several limitations to this study. Firstly, as a cross-sectional study it does not identify causality, but association. For example, a relationship was identified between insole use and pain in the calf and ankle in the multivariate analysis. We do not know if this is a causative association or whether the insole was used to reduce the pre-existing pain. With some potential factors identified by association, future research should use prospective research designs to investigate possible causality. While this study only considered physical activity in work, it is known that activity outside of work also impacts WMSD (Locks et al., 2018) and should be considered in the future alongside factors such as previous injury history and perhaps even menstrual pain given the predominantly female population. Secondly, self-

reported measures of factors such as height, weight and physical activity are not always reliable (Engstrom et al., 2003; Gorber et al., 2007; Prince et al., 2008). Finally, there was possibly a participation bias, for example an increased likelihood of filling out the questionnaire if the respondent suffered from MSD or were not satisfied with the footwear provided by their place of work.

Conclusion

This work identifies a high prevalence of WMSD in this population of surgical workers, for which footwear appears to be an influencing factor. Specifically, it identifies the importance of considering factors including footwear fit, footwear comfort, footwear choice, how footwear is provided by employers and the need to investigate other factors such as rotating between multiple pairs of footwear. As a result, future WMSD research should consider footwear due to its identified association with WMSD in the lower body and should endeavour to determine how footwear can be used to reduce WMSD and improve foot health in workers undertaking prolonged periods of standing.

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