

Identifying Lower Limb Problems And The Types of Safety Footwear Worn In The Australian Wine Industry: A Cross-Sectional Survey.

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Abstract

Background: The Australian wine industry is a valuable part of the wider Australian economy worth approximately AUD\$45 billion annually and employs 163,790 people either full time or part time. Australian agricultural industries are amongst the nation's most dangerous workplaces with joint, ligament, muscle and tendon injuries being commonplace along with wounds, lacerations and musculoskeletal diseases. It is therefore important to try and minimise the risk of injuries to workers as much as possible. The aims of this study were to (1) identify the types of lower limb problems that occur in the Australian wine industry and (2) identify the types of safety footwear used.

Methods: Participants were recruited from the Australian wine industry. The study was a cross sectional anonymous survey of 82 questions with n=207 respondents. Questions related to job role performed, types of lower limb problems experienced, level of pain, restriction of activities, types of footwear worn, general health and physical health.

Results: The main working roles were 73.4% winery, 52.2% vineyard, 39.6% laboratory, 32.4% cellar door and 8.2% office, with 63.3% of participants working in more than one role. Lower back pain was the most commonly reported problem at 56% followed by foot pain 36.7%, knee pain 24.6%, leg pain 21.3%, ankle pain 17.9%, hip pain 15.5%, toe pain 13% and heel pain 11.1%. The most popular footwear used by participants was the elastic sided safety boot, followed by a high cut lace up safety boot with side zip. Overall, although the pain experienced was moderate to severe, it did not impact the workers ability to perform their duties and the majority self-reported as being in very good general and physical health.

Conclusion: To date no data has been published on the frequency of lower limb problems or the types of safety footwear worn in the Australian wine industry. This study demonstrated that elastic sided safety boots were the most popular amongst respondents and with that, certain lower limb problems can occur. Therefore, further research into the safety footwear used is needed to better support workers health while working in varied roles and conditions.

Background

The Australian wine industry is a valuable part of the wider Australian economy worth approximately \$45 Billion Australian dollars annually and employs 163,790 people either full time or part time [1]. Therefore, the wine industry and the health and safety of its workers are an important part of Australian society and the economy. The industry is also somewhat unique in that most businesses are small to medium in size and consist of multiple workplace environments within the one business. It has been said that the Australian wine industry consists of a small number of large businesses and large number of small businesses [2]. In 2020 there were 2361 wineries and 6251 grape growers in Australia. Approximately 64% of producers are considered small to medium and process less than 50 tonnes of grapes per year. While 20% of businesses process 50–499 tonnes per annum, and the remaining 16% process more than 500 tonnes per annum [2].

A typical wine business may include a winery, vineyard, laboratory, office and a cellar door sales/hospitality outlet. Business owners and employees may work in various combinations of roles across the business, particularly in smaller family run businesses. Small wineries are comprised of a primary industry (grape growing), a secondary process (wine production) and tertiary activities such as restaurants and cellar door sales [3].

Grape growing activities can include operating heavy machinery as well as driving tractors and harvesters in the vineyard. Winery activities can include operating forklifts/pumps/crushers/conveyor belts and bottling machines, along with analysing juice and wine samples in the laboratory plus general office work. Sales and hospitality work in the cellar door can often include food service. Most of these activities involve wearing protective safety footwear and standing for long periods. This is particularly the case during the vintage/harvest season when the weather is very hot and shifts are longer than usual due to the time constraints involved in harvesting and processing grapes at the optimal time.

To date no data has been published on the types of injuries experienced in the Australian wine industry. However, the South Australian government, which is the largest wine production area in Australia and accounts for 52% of the national output, publishes data on workplace injuries across several industries [2, 4]. While the wine industry is predominantly an agriculture endeavour, it is comprised of activities such as manufacturing, technical/trade, labouring, machinery operating/driving, professional activities and hospitality/sales work. The majority of injuries reported by the South Australian government across all industries in 2020 were for technicians/trade workers (27.9%), labourers (26.6%) and machinery operators/drivers (16%). The injuries were predominantly upper limbs (38.5%), lower limbs (18.9%) and trunk/back (17.9%). The nature of the injuries were mainly traumatic joint/ligament/muscle/tendon injuries (37%), wounds/lacerations (29.1%) and musculoskeletal diseases (15.2%). The main mechanism for these injuries were body stresses (34.5%), being hit by an object (19.4%) and falls/trips/slips (17.3%) [4].

Bernard et al [5], surveyed French vineyard workers and suggest that both biomechanical and psychosocial factors may play a role in musculoskeletal pain. They found upper limb pain (31.2%), neck/shoulder (28.9%), lower limb (25%) and back pain (55%) prevalence during grapevine pruning and grape harvesting. Harith et al [6] describe manual harvesting as still being prevalent in agriculture industries and is the largest contributor to work-related musculoskeletal disorders.

Mitchell and Lystad [7] reported that in the Australian aquaculture industry, 37.3% of injuries were body stressing events and lower limb injuries accounted for 20.3% of all injuries.

Anderson et al [8] state that 50% of workers are exposed to the risk of musculoskeletal disorders due to spending prolonged hours standing at work, these can include lower back, lower extremity and foot disorders. They also suggest that the flooring, footwear and the body are inextricably linked and all three of these factors must be considered when assessing workers experiencing workplace musculoskeletal disorders. Australian agricultural industries have been described as being amongst the nation's most dangerous workplaces [9].

Safety boots are compulsory in many occupations to protect the feet of workers from external stimuli, particularly in harsh environments [10]. The unique environmental conditions and tasks in different occupations necessitates a variety of boot designs to match each workers occupational requirements. Unfortunately, safety boot are often designed more for safety at the expense of functionality and comfort [10]. Dobson et al [11] surveyed Australian underground miners and found there was a great dissatisfaction with their work boot design. Over half of the miners believed their work boots contributed to their lower limb pain and reported that their boots were uncomfortable. Different working roles and environments caused different incidences of foot problems, lower limb pain and comfort scores. They conclude that one boot design cannot meet all the requirements of underground coal mining [11].

Other risk factors for agricultural workplace injuries include working full time, being the owner/operator, medication use, prior injury, poor health, stress/depression and poor hearing [12]. Heat stress has also been highlighted as a risk factor for occupational injuries in the horticulture industry in Australia [13].

During vintage, grape harvesting and processing will often be performed in shifts due to the unpredictability of grape ripeness and winery logistics. Research on the effects of inadequate sleep on shift workers in Australia has shown that it can have an impact on alertness, work performance and risk of injury resulting in incapacity and even fatality [14]. Likewise, 11% of European shift workers experienced an 'occupational accident absence' and that doing shift work is significantly associated with occupational accidents [15].

When these risk factors and the nature of wine industry work are taken into consideration, especially during the busy vintage/harvest period, it is important to try and minimise the risk of injuries to workers as much as possible. Therefore, the aims of this study were to (1) identify the types of lower limb problems that occur in the Australian wine industry and (2) identify the types of safety footwear used.

Methods

2.1 Survey design and testing

The study was cross sectional with the design based on previous validated surveys, questionnaires and studies that investigated foot health [16], musculoskeletal discomfort [17, 18] and the footwear needs of workers [11, 19]. Content validity was considered via discussions with Podiatry, Physiotherapy, Occupational injury and wine industry representatives and the survey questions were modified so as to be appropriate for the wine industry and capture the relevant areas of concern. Reliability was established by trialling the survey on 10 participants who completed the survey anonymously. Four weeks later the same 10 participants completed the survey a second time to test for repeatability and to ensure the questions were well understood.

The final survey consisted of 82 closed-ended questions (Likert scale and choose all that apply), that were divided in to nine sections including job role, lower limb problems at work, treatment sought, severity

of pain, limitations caused by lower limb problems, types of footwear worn at work, footwear fit & comfort, general health and physical health.

Participants were recruited by several methods: writing to wine and grape industry bodies throughout Australia requesting surveys be distributed to members, supplying surveys to the work health and safety manager of the largest corporate wine company in Australia, emailing wine industry workers at the University of Adelaide and online via wine industry social media groups. Participants self-selected to complete the anonymous survey (n = 207) and the survey was open for two weeks after the Australian vintage/grape harvest period in May 2021.

For large populations, it is recommended that surveys have a sample size of 188 for 90% confidence level and 267 for 95% confidence level [20]. Therefore, for n = 207 and confidence level of 95%, the confidence interval was calculated as 6.8% [21].

Human Research Ethics Committee approval for the survey was given by the University of Adelaide (H-2020-267). An implied consent statement was placed at the beginning of the survey indicating that continuation with the questionnaire implied the participants consent.

2.2 Survey items

2.2.1 Job role

Participants were asked what job roles they performed in the Australian wine industry in the last 12 months. The question was a choose all that apply, closed-ended question with the option that workers could have several different roles within their workplace.

2.2.2 Lower limb problems at work

Lower limb aches, pain and injuries were assessed by asking participants if they had experienced any problems in different body areas in the last 12 months. If the participant had no lower limb problems, they were directed to the footwear section of the survey.

2.2.3 Treatment sought

For those participants that had experienced lower limb problems at work they were asked if they had been hospitalised due to these problems or if they had sought any treatment.

2.2.4 Severity of pain

A Likert scale was used for participants to rate their pain (1 'low' to 5 'severe'). Likewise, a Likert scale (1 'never' to 5 'always') was used to determine; the frequency of pain, if pain limited work duties possible and any difficulties in completing work activities (Table 1).

2.2.5 Limitations caused by lower limb problems

The final question regarding lower limb problems was related to how these problems affected daily activity in general, not only in work situations. A Likert scale (1 'not at all' to 5 'always') was used to rate any limitations (Table 2).

2.2.6 Types of footwear worn

Participants were asked a closed-ended question relating to the style of footwear they most often used at work. A choose all that apply format was used and they were also asked if they use any additional support or cushioning in these shoes. The types of footwear were separated in to two groups: safety or non-safety (Table 3).

2.2.7 Footwear fit and comfort

Participants were asked to rate their impression of their footwear's fit and comfort using a Likert scale (1 'strongly disagree' to 5 'strongly agree') over a series of 19 questions (Table 4).

2.2.8 General Health

Participants were asked to rate their general health with a Likert scale (1 'poor' to 5 'excellent') and answer nine questions relating to their general wellbeing using a Likert scale (1 'definitely false' to 5- 'definitely true') (Table 5).

2.2.9 Physical health

The final five questions related to general physical health and participants used a Likert scale (1 'definitely false' to 5 'definitely true') to rate their responses (Table 6).

2.3 Statistical analysis

Data sorting and preparation was conducted with Microsoft Excel 2010, the closed-ended questions and Likert scale questions were counted to determine frequencies. Descriptive statistics and one-way ANOVA for the reliability trial were performed using the statistical package XLSTAT (version 2019.4.2, Addinsoft SARL, Paris, France).

Correspondence analysis (Table 7) and Polychoric correlation factor analysis (Table 8) was performed on the binary data relating to; job role, area of lower limb problem and type of footwear worn using the statistical package XLSTAT (version 2019.4.2, Addinsoft SARL, Paris, France). Polychoric correlation factor analysis is the preferred method for studying the construct validity of exploratory and confirmatory data when using Likert scales and binary questionnaires [22].

Results And Discussion

3.1 Reliability trial

One-way ANOVA analysis for the repeated trial survey demonstrated that there were no significant differences between the responses for each question after 4 weeks, p-values for each question ranged

from 0.15 to 1.0.

3.2 Job Role

The main working roles reported by the participants were 73.4% winery, 52.2% vineyard, 39.6% laboratory, 32.4% cellar door and 8.2% office. Interestingly 63.3% of participants worked in more than one role, highlighting the multifaceted nature of wine industry work. While this survey did not explore the nature of the work involved in each role, i.e., time spent standing, walking or sitting, previous research has reported that an estimated 50% of the working population experience musculoskeletal disorders due to prolonged standing and that standing is implicated in lower back, lower limb and foot pain [23, 24].

3.3 Lower limb problems

Lower back pain was the most commonly reported problem at 56% followed by foot pain 36.7%, knee pain 24.6 %, leg pain 21.3%, ankle pain 17.9%, hip pain 15.5%, toe pain 13% and heel pain 11.1%. If foot, toe and heel pain are combined to total foot pain 60.8% of respondents experienced some type of foot pain. These results compare with those reported for miners and their work boots, that is, lower back pain 44.5%, foot pain 42.3%, knee pain 21.5% and ankle pain 24.9% [11].

Possibly due to the self-selection nature of the survey, only 19.3% of respondents reported no lower limb problems, this is a common limitation of such surveys [11]. Participants who reported no problems at work were directed to the footwear, general and physical health question section.

3.4 Treatment sought

The most common practitioner survey participants sought out for treatment were Physiotherapists at 36.2%. Surprisingly, the same frequency of participants sought no treatment for their problems. General practitioners/medics were seen 18.8%, podiatrists and massage therapists 18.4%, chiropractors 16.4%, osteopaths 6.3%, surgeons 5.8% and 14% had been hospitalised because of their problems.

3.5 Severity of pain

For participants that reported lower limb problems while working was is in the 'mild' to 'moderate' range. How often this pain was experienced was in the 'occasionally' to 'many times' range. Whether the pain limited work duties or caused difficulties performing work activities were in a similar range (Table 1).

Table 1
Responses to questions relating to severity of pain at work

Question	Mean	SD
(a) Rate the level of pain you experienced in the last 12 months.	3.47	0.96
(b) How often did you experience this pain?	2.94	1.01
Were you limited in the duties you could do at work?	2.12	0.99
Has it caused you to have difficulties in your work activities?	2.26	0.89
Response range and definition: (a) 1-low, 2-very mild, 3-mild, 4-moderate, 5-severe. (b) 1-never, 2-occasionally, 3-many times, 4-very often, 5-always. Mean- response mean, SD- standard deviation.		

3.6 Limitations caused by lower limb problems

Overall the pain experienced by participants did not limit their ability to perform several activities (Table 2). Most activities had a mean value of between 1 'not at all' and 2 'a little'. Only vigorous activities, bending and climb a hill were in the 'a little' to 'moderate' range. Therefore, when we consider that although the pain experienced by participants was in the 'mild' to 'moderate' range (Table 1) and that it was experienced 'occasionally' to 'many times', it did not however have a large impact on the ability for workers to complete their daily activities. This could explain the unwillingness of participants to seek treatment for lower limb problems.

Table 2: Response to question; during a typical day how much does this pain interfere with the following activities.

Question	Mean	SD
Vigorous Activities	2.65	1.19
Moderate Activities	1.98	0.91
Lift small objects such as shopping bags	1.59	0.86
Climb a hill	2.06	1.15
Walk up a flight of stairs	1.84	1.1
Bend	2.20	1.13
Walk 1km	1.89	0.99
Walk 100metres	1.51	0.78
Shower yourself	1.36	0.68
Response range and definition: 1-not at all, 2-a little, 3-moderately, 4-very often, 5-always. Mean- response mean, SD- standard deviation.		

3.7 Types of footwear worn

The most popular footwear used by participants was the elastic sided safety boot, followed by a high cut lace up safety boot with side zip (Table 3). Additional support or cushioning in shoes was reportedly used by 31.4% of the respondents, however no details on the types of support or cushioning were recorded. That is, whether it was a custom-made foot orthosis or an off the shelf insole. Dobson et al [11] reported that in the mining cohort they studied, only 6.7% of respondents wore health professional prescribed orthoses. Flat insoles and contoured foot orthoses have been demonstrated to have an effect on plantar pressure and tibial acceleration when used in high cut, lace up, boots [25]. However, no differences in 'boot comfort' between the no insole, flat insole and contoured foot orthosis groups were identified in this previous study [25].

Table 3
Response to types of footwear most often worn at work

Boot Style	Frequency %
Elastic sided safety boot	46.4
High cut lace up safety boot with side zip	25.1
Sports shoe	15.0
High cut safety boot with laces	14.0
Elastic sided boot (not safety)	9.7
Rubber/Wellington/Gum boot	9.7
Dress shoe	9.7
Low-Mid cut safety boot with laces	7.7
Use additional support or cushioning in your shoes	31.4

3.8 Footwear fit and comfort

The majority of participants reported that their work footwear was comfortable (Table 4), however 33.8% reported that their shoes made their feet ache at work and 41.1% reported their shoes made their feet hurt after work. More than half of the respondents reported their boots as being hot and not having good ankle support. Respondents reported difficulty in finding shoes that did not hurt their feet, finding shoes to fit their feet and that their shoes were heavy. Heavy footwear has been associated with increased energy expenditure by workers wearing safety footwear [26]. Dobson et al [11] report that 62.3% of miners believed that their foot and ankle pain was related to their work boots. One explanation for this is that miners may be wearing boots that are longer than their feet, possibly because boots in their correct length are too narrow [27]. Dobson et al [28] concluded that traditional fitting methods based on foot length were insufficient when fitting miners. Grau and Barisch-Fritz [29] concur and state that foot width and girth measures are different in static and dynamic loading situations and must be considered when

manufacturing and fitting safety footwear to aid in supporting workers health. Buldt and Menz [30] state that between 63 and 72% of the general population are wearing inappropriately sized footwear based on length and width measurements, and that incorrect footwear fitting is significantly associated with foot pain.

Overall, respondents thought their shoes had good grip, their shoes were easy to take off and put on, their shoes fit well and they felt safe and protected when wearing their footwear.

Table 4
Responses to questions regarding the fit and comfort of the footwear worn

Question	Mean	SD	Disagree (%)	Agree (%)
It is hard to find shoes that do not hurt my feet.	2.87	1.39	49.3	37.2
I have difficulty in finding shoes that fit my feet.	2.83	1.30	49.2	38.1
I am limited in the number of shoes that I can wear.	2.96	1.33	46.4	46.9
My shoes are comfortable.	3.59	1.00	18.4	63.8
My shoes have good arch support.	3.16	1.05	29.0	38.2
My shoes are cushioned.	3.47	0.99	18.4	58.5
My shoes make my feet ache when I am at work.	2.96	1.26	40.1	33.8
My shoes make my feet hurt after work.	3.01	1.25	41.5	41.1
My shoes have good grip.	4.10	0.74	3.4	85.5
My shoes make my feet feel hot.	3.41	1.03	23.2	56.5
My shoes are durable.	3.63	0.95	15.0	67.6
My shoes are easy to put on and take off.	4.01	0.96	10.6	79.2
My shoes fit well.	3.82	0.98	14.0	73.9
My shoes are heavy	3.55	1.02	17.9	58.9
My shoes are good value for money.	3.48	1.02	12.1	50.7
I like the style of my shoes.	3.68	1.00	12.6	63.8
I feel safe and protected when wearing my shoes.	4.02	0.76	2.9	79.7
My shoes provide good ankle support.	3.37	1.08	28.5	54.6
My shoes are waterproof.	2.70	1.14	51.2	30.9
Response range: 1-strongly disagree, 2-disagree, 3-neither agree nor disagree, 4-agree, 5-strongly agree. Mean- response mean, SD- standard deviation.				

3.9 General Health

The majority of participants general health was reported as being 'very good' to 'excellent' on the Likert scale, while very few reported their health as 'fair' to 'poor' (Table 5).

Overall, the participants agreed with statements describing themselves as healthy and happy. They were as 'healthy as anyone I know', full of life, calm and happy.

However, 54.1% agreed with the statement 'I feel tired' and 21.7% agreed with the statement 'I feel depressed'. This figure for depression is similar to that reported by the Australian Bureau of Statistics [31] where 20.1% of Australians reported themselves as having an anxiety-related condition and depression or feelings of depression.

Table 5
Response to general health and wellbeing questions

Question	Mean	SD	% 1–2	% 4–5
(a) How would you describe your general health?	3.81	0.67	1.5	69.1
(b) I seem to get sick a lot easier than most people	1.68	0.85	66.7	4.3
I am as healthy as anybody I know	3.78	0.97	12.1	73.4
I expect my health to get worse	2.61	1.14	44.9	23.7
My health is excellent	3.67	1.04	19.3	71.5
I feel full of life	3.56	1.04	23.2	61.8
I feel tired	3.24	1.25	36.7	54.1
I feel calm	3.42	1.04	27.1	59.9
I feel happy	3.80	0.95	15.5	74.4
I feel depressed	2.29	1.16	65.2	21.7

Response range: (a): 1-poor, 2-fair, 3-average, 4-very good, 5-excellent. (b): 1-definitely false, 2-mostly false, 3-don't know, 4-mostly true, 5-definitely true. Mean- response mean, SD- standard deviation.

3.10 Physical health

The participants reported on the whole that their overall physical health did not impede the types of activities they were able to achieve during work. Mean values for all questions relating to physical health ranged from 'definitely false' to 'mostly false' on the Likert scale (Table 6).

Table 6

Responses to the questions; during the past 12 months, how much of the time have you had any of the following problems with your work or other activities as a result of your physical health?

Question	Mean	SD
Reduced the amount of time you spent on work or other activities.	1.68	0.80
Accomplished less than you would like.	1.85	0.85
Were limited in the kind of work or other activities.	1.87	0.89
Took extra time performing work or other activities.	1.89	0.83
Interfered with normal social activities with family and friends.	1.53	0.76
Response range and definition: 1-definitely false, 2-mostly false, 3-don't know, 4-mostly true, 5-definitely true. Mean- response mean, SD- standard deviation.		

3.11 Statistical analysis

Polychoric correlation factor analysis was performed on data relating to job role, lower limb problem and type of footwear worn (Table 7). Fourteen correlations were identified but only two correlations relating to job role were seen. That is, working at the cellar door and wearing sports shoes and a negative correlation for working in the office and wearing low-mid cut safety shoes as well as toe pain. The negative correlation indicates that a person working in an office is less likely to wear low-mid cut safety shoes and less likely to have toe pain. Wearing gum boots and knee pain had a moderate correlation while wearing low-mid cut safety shoes was negatively correlated with hip pain. Wearing dress shoes was negatively correlated with heel pain and ankle pain. Finally, wearing elastic sided boots was negatively correlated with hip, ankle and leg pain.

Correspondence analysis showed significant association between footwear worn and lower limb problem. In particular elastic sided safety boots were associated with hip, ankle, leg, lower back and foot pain (Table 8). High cut lace up safety boots with side zip were associated with heel, foot, toe and lower back pain. High cut lace up safety boots were associated with leg and ankle pain. Gum boots were associated with knee and ankle pain.

Table 7: Summary of polychoric correlation matrix of variables job role, footwear worn and lower limb problem (full matrix in additional file 1).

Variables	Correlation
Foot pain x Toe pain	0.8
Heel pain x Toe pain	0.8
Cellar Door x Sports shoes	0.6
Leg pain x Ankle pain	0.5
Leg pain x Foot pain	0.5
Knee pain x Gum boot	0.5
Toe pain x Office	-0.9
Hip pain x Low-Mid cut safety shoe	-0.9
Hip pain x Elastic sided boot	-0.9
Heel pain x Dress shoes	-0.9
Ankle pain x Elastic sided boot	-0.9
Ankle pain x Dress shoe	-0.9
Leg pain x Elastic sided boot	-0.9
Office x Low-Mid cut safety shoe	-0.8
Moderate correlation 0.5 to 0.7, high correlation 0.7-1.0 Negative correlation indicates inverse relationship of variables.	

Table 8: Correspondence analysis of relationship between the footwear worn and the lower limb problem.

	ElastBS	LaceZip	HSBL	LMSBL	ElasB	Sport	Gum	Dress
Lower back	32%	20%	12%	3%	6%	10%	7%	11%
Hip	45%	18%	5%	0%	0%	14%	9%	9%
Leg	39%	14%	18%	7%	0%	12%	7%	4%
Knee	31%	17%	10%	3%	4%	15%	15%	5%
Ankle	40%	7%	18%	4%	0%	16%	15%	0%
Feet	32%	24%	8%	9%	6%	9%	6%	7%
Heel	20%	31%	6%	6%	14%	6%	17%	0%
Toe	30%	23%	5%	14%	5%	9%	9%	5%

$\chi^2 = 82.9$, p-value 0.002, $\alpha = 0.05$. ElastBS- elastic sided safety boot, LaceZip- high cut lace up safety boot with side zip, HSBL- high cut lace up safety boot, LMSBL- low/mid cut lace up safety boot, ElasB- elastic sided boot, Sport- sports shoe, Gum- gum/wellington boot, Dress- formal or dress shoe. ElasB- elastic sided boot, Sport- sports shoe, Gum- gum/wellington boot, Dress- formal or dress shoe.

From these results, it can be seen that the elastic sided safety boot is the most popular, followed by the high cut lace up safety boot with side zip. Even if the high cut lace up safety boot is considered analogous to the high cut lace up safety boot with side zip, the elastic sided safety boot is still the most popular. Also, workers that wear elastic sided safety boot are more likely to experience lower limb problems such as foot and lower back pain. Safety footwear was also reported as being hot, heavy and providing poor ankle support. Many studies have explored the relationship between safety footwear and injuries with the majority focusing on; high cut lace up safety boots, military boots, gum boots, sports shoes [10] and surgical clogs [23]. These studies have identified many relationships, for example, gum boots are associated more with knee and heel pain while high cut lace up safety boots were associated with more leg and ankle pain [32]. Gum boots are associated with more force and contact area in the heel compared to the high cut lace up safety boots [33]. High cut lace up safety boots with varying sole and shaft stiffness are associated with effects on lower limb muscle activity, ankle motion [34] and plantar pressures [35]. High cut lace up safety boots also have an impact on postural control [36] and postural stability under workload [37]. High cut lace up military boots while carrying a workload also have an effect on postural stability and heel contact during slip events [38, 39].

However, to date no data exists on the effect of elastic sided safety boots in any industry. The popularity of the elastic sided safety boot in the Australian wine industry is a unique phenomenon and its use therefore may be more due to tradition. Elastic sided boots were developed in the early 1900s to withstand the harsh, unforgiving environment of the Australian outback by providing a boot that was comfortable, rugged and able to cope with both hot/dry and cold/wet seasons [40]. They became popular heavy-duty footwear for farming, forestry, mining, and industrial uses [40]. Another reason for the

popularity of the elastic sided safety boot may be the nature of the work in the Australian wine industry. As has been highlighted, many wine businesses require workers to perform varying jobs over different sites and conditions, this often involves a quick change of suitable footwear, 79.2% of respondents agreed with the statement that their shoes are easy to put on and take off, which could also help to explain the popularity of elastic sided safety boots.

Boot design features have been shown to have an influence on the lower limbs depending on the task being performed and the supporting surface [10]. Therefore, occupational specific testing of footwear effects should occur in order to try and accommodate for individual workplace environments.

Conclusion

This study has shown that lower limb problems are a concern in the Australian wine industry and that even if a problem is present workers often do not seek treatment or let the problem interfere with their work activities. This may be a function of the vintage/harvest season, when harvesting and processing grapes at their optimum condition places time constraints on workers. The study also demonstrated that elastic sided safety boots were the most popular amongst respondents and with that, certain lower limb problems can occur.

These factors highlight the need for further research into the footwear used in the Australia wine industry to better support workers health while working in varied roles and conditions. A comparison of different footwear in different environments could take place as well as exploring the time taken for footwear to deteriorate in these environments. The optimum length of efficacy of the footwear could also be assessed to ensure footwear is replaced at appropriate times and not used when worn excessively.

As is the case with all surveys, there are limitations to this study and the accuracy of self-reported measures. Therefore, it is not possible to conclude whether specific job roles had higher risks for lower limb problems with specific footwear.

Abbreviations

AUD: Australian Dollars

ANOVA: Analysis of variance

ElastBS: elastic sided safety boot

LaceZip: high cut lace up safety boot with side zip

HSBL: high cut lace up safety boot

LMSBL: low/mid cut lace up safety boot

ElasB: elastic sided boot

Sport: sports shoe

Gum: gum/wellington boot

Dress: formal or dress shoe.

Declarations

Availability of data and materials

The dataset used and analysed during this study is available from the corresponding author on reasonable request.

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Contributions

All authors contributed to the design, registration, conduct and reporting of this research. AC completed the quantitative analysis. All authors read and approved the final manuscript.

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Ethics Declaration

Ethics approval and consent to participate

Ethical permission to undertake this work was granted by the University of Adelaide (H-2020-267). All participants consented to take part in this research and for the findings to be published.

Consent for publication

Consent to publish research findings was obtained from all participants prior to their participation in this project. No personal identifiable data is included within this publication.

Competing interests

The authors declare that they have no competing interests.

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