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ARTICLE

Worker and work-related factors influence on musculoskeletal symptoms among veterinary surgeons

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ABSTRACT

Worker and work-related musculoskeletal symptoms are prevalent among surgeons operating on human patients. Despite incidence rates for accidents among veterinarians and their staff being 2.9 times higher than that of general practitioners of human medicine, little is known about musculoskeletal symptoms among veterinary surgeons. In this study, 212 board-certified members of the American College of Veterinary Surgeons responded to a survey regarding various work-related activities and their experience with musculoskeletal symptoms in 10 different body regions. Across all body regions, reported pain increased from before to after a typical day of surgery ($p < .01$). Gender, weight, age, and years performing surgery were worker factors that were related to pain ($p < .05$), while number of procedures, practice focus, and proportion of minimally invasive surgery were work factors related to pain ($p < .05$). Our findings suggest that musculoskeletal symptoms are prevalent among veterinary surgeons and may help provide evidence for guidelines for minimising musculoskeletal injuries in veterinary surgery.

Practitioner summary: Little is known about the risk factors for musculoskeletal symptoms (MSS) among veterinary surgeons. This cross-sectional survey of veterinary surgeons investigates worker and work factors related to MSS. We show that MSS are prevalent and identify key factors providing evidence that MSS are a concern in veterinary surgery.

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KEYWORDS
Musculoskeletal disorders; veterinary surgery; workplace ergonomics; work-related risk factors

1. Introduction

Veterinary workers care for the health and well-being of animal patients. Often, workers in animal medicine must practice in a broad range of work environments with various species of different sizes ranging from a few hundred grams to thousands of kilograms, which are factors that can influence their risk and the assessment of their risk factors for musculoskeletal symptoms. Incidence rates for accidents among veterinarians and their staff have been shown to be 2.9-times higher than for general practitioners of human medicine, who focus on only one species (Nienhaus, Skudlik, and Seidler 2005). Musculoskeletal disorders (MSD) have been investigated in general veterinarians, veterinary sonographers, and veterinary echocardiographers (Gilkey et al. 2011; MacDonald and King 2014; Scuffham et al. 2010; Seagren et al. 2022). These have shown similar results to studies on practitioners working with human patients, with 62% of veterinary sonographers reporting musculoskeletal symptoms (Gilkey et al. 2011). Among veterinary echocardiographers, gender and weeks per year performing echocardiograms predicted musculoskeletal pain (MacDonald and King 2014). The prevalence of musculoskeletal symptoms was reported to be as high as 96% in general veterinarians (Scuffham et al. 2010). However, little is known about veterinary surgeons.

Although there are significant differences between surgeons for animal and human patients, studies on human surgeons have shown that surgical work is physically demanding, often requiring non-neutral postures held for long durations (Berguer et al. 1997; Dalager et al. 2019; Nimbarte et al. 2012; Szeto et al. 2009; Zhu et al. 2014). Previous studies on MSD prevalence in surgeons for human patients have shown that musculoskeletal symptoms (MSS) including pain were reported by up to 93% of surgeons (Dalager et al. 2019; Soueid et al. 2010; Stucky et al. 2018). Key risk factors in human surgery include posture, workstyle, procedure length, number of procedures, and years performing surgery (Athanasiadis et al. 2021; Cass,

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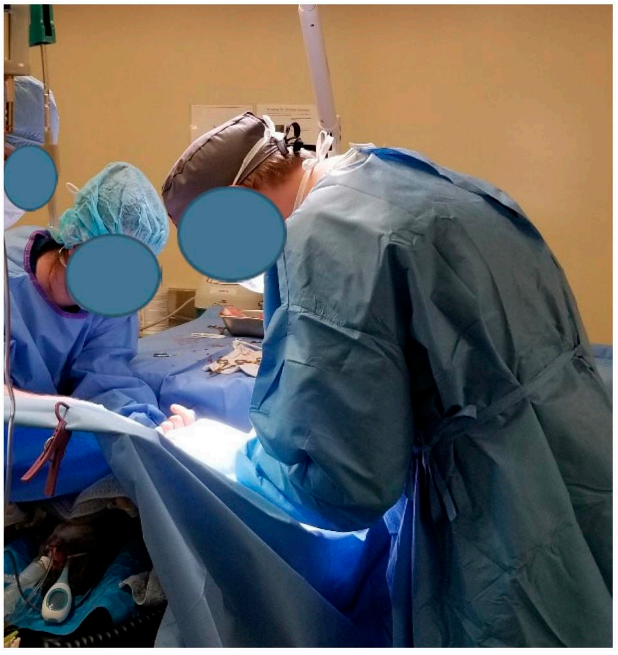

Figure 1. A veterinary student is seen with their head forward and bending at the neck to perform an ovariohysterectomy (spay) on a cat.

Vyas, and Akande 2014; Harvin 2014; Schlussel and Maykel 2019; Szeto et al. 2009; Yang et al. 2021). This previous literature on surgeons who operate on human patients suggests significant physical ergonomic risk factors associated with the surgical work demands; risk factors that are likely also present in surgical work on animal patients. Figure 1 illustrates how non-neutral positions must be held by veterinary surgeons in the work environment. These risk factors have been looked at previously (Kim et al. 2023); however, how the unique veterinary worker and work risk factors influence MSDs remains unknown.

Worker factors among veterinary surgeons differ from human medicine. Females represent only 26% of general surgeons, while female veterinary surgeons make up 58% of the workforce (RCVS 2021; US Bureau of Labour Statistics 2022). The veterinary field also struggles from a workforce shortage and higher annual turnover than human physicians (Lloyd 2022; Salois 2021).

Work factors in veterinary medicine also vary greatly from human medicine. Veterinary surgeons work with species that have a wider range of sizes and shapes when compared to their human patient counterparts (Kim et al. 2023). Veterinary surgeons often perform a broad spectrum of surgical procedures, often utilising the same instrumentation as human surgeons. Large animals such as horses and cattle may have surgery provided by a practitioner that also operates on small animals such as cats. In contrast to subspecialties in human medicine, there are less specific work environments, such as procedure-specific operating room settings. This is due to the wide range of animal sizes, which may include patients that are many times larger than the surgeon performing the procedure. Due to the size of large animals, the veterinary surgeon may need to bend at the waist and hold non-neutral positions to perform a procedure. This unique dynamic has been shown to lead to higher rates of occupational hazards such as bites, scratches, kicks, and trampling that human patient counterparts are less likely to encounter (Epp and Waldner 2012). This dynamic further suggests the potential for veterinary surgeons to exhibit different work-related factors for musculoskeletal symptoms when compared to general veterinarians. Understanding the various worker and work factors affecting MSS in veterinary surgeons may aid in the creation of organisational guidelines to help reduce the prevalence and impact of musculoskeletal injuries in the profession. Therefore, this study aims to understand the relationship between worker and work factors with veterinary surgeons' risk for MSS.

2. Methods

2.1. Study population

The study population were diplomates of the American College of Veterinary Surgeons (ACVS) who were practicing with at least one year of post-residency experience as well as retired veterinary surgeons in February 2021 based on the ACVS webpage (www.ACVS.org). All ACVS members within the target population were surveyed. No exclusion criteria were used, and only board-certified surgeons were included.

2.2. Study design and data collection

This study was reviewed and approved by the Purdue University institutional review board (IRB-2020-1092). E-mail contacts for boarded veterinary surgeons were identified in the ACVS webpage in February 2021, and individualised links to an online survey were e-mailed. A reminder was sent to all surgeons listed one week after the initial e-mails. Responses were collected between April 8th, 2021 and April 24th, 2021. No participants were financially compensated.

2.3. Questionnaire design

The survey was developed using REDCap (Harris et al. 2019), which allowed for data collection with no identifiable link to respondents (Appendix B). A multidisciplinary team of certified professional ergonomists and veterinary surgeons modified existing surveys for assessing ergonomics and musculoskeletal symptoms for veterinary surgeons (A. E. Park et al. 2017; Plerhoples, Hernandez-Boussard, and Wren 2012). The survey was estimated to take 5–10 minutes to complete. A brief communication with no statistical analyses has been previously reported with a subset of the data (Kim et al. 2023).

2.3.1. Worker factors

The survey asked participants questions about their demographics including age, gender, height, weight, dominant hand, hand size, and training level.

2.3.2. Work factors

Work factors in the survey questions included years performing surgery, practice emphasis in animals and surgery, employment setting, time performing surgery and number of procedures per week, and body position during surgery. Additionally, the survey questioned about efforts to minimise musculoskeletal symptoms if participants had experienced symptoms.

2.3.3. Outcome measurements

The survey included questions regarding musculoskeletal symptoms in 10 body regions experienced within the past year. For each body region, participants were asked if they had experienced any stiffness, pain, fatigue, numbness, or limited function within the past year. Additionally, participants were asked to rate their pain/discomfort prior to a typical surgery day and after a typical surgery day on a scale from 0 to 10 (0 = No Pain, 10 = Worst Possible) for each body region. From this, a difference was calculated by taking the post-surgery day rating less the prior to a surgery day rating.

2.4. Data analysis

Statistical software R (v. 4.2.1) was used for statistical analysis; the ggplot2 library was used for visualisation. The Shapiro-Wilk normality test was used to determine normality for all variables individually. Due to non-normality, non-parametric pairwise statistical analysis was performed using the Kruskal-Wallis and Wilcoxon signed rank test.

Ratings for all body regions for both before and after a typical surgery day were determined to be non-normal ($n = 145$, $p < .001$) through the Shapiro-Wilk test. The resulting difference between before and after for each body region was also found to be non-normal.

Due to the non-normality, a paired Wilcoxon signed rank test was performed on all before and after surgery ratings for each body region. The effect size r was calculated for each body region (Tomczak and Tomczak 2014).

The Kruskal-Wallis rank sum test was used for comparing after surgery pain/discomfort ratings with categorical factors (e.g., number of years performing surgery) for all body parts. For these comparisons, a Dwass-Steel-Crichtlow-Fligner post-hoc test was performed to determine differences between levels within each significant factor.

3. Results

The survey was disseminated to 1,031 ACVS diplomates with 219 responses. Of these, seven were fully incomplete and not considered. A total of 212 respondents were analysed for this study, corresponding to a 20.5% response rate.

The respondents were 44% female and 56% male with the majority (61%) performing minimally invasive surgery 1–25% of the time (Table 1). Participants had varying years of experience performing surgery, with 33.5% having between 11 and 20 years of experience and 27.8% having more than 30 years of experience. Participant age showed a similar distribution with 32.1% of participants between the ages of 41 and 50, with 23.6% of participants older than 60. Most participants (94%) reported MSS in at least one body region, with a majority (>50%) of participants reporting at least one MSS in the neck, upper back, lower back, and/or right wrist and hand (Table 2).

3.1. Reported change in pain and discomfort before and after surgery

Approximately 68% ($n = 145$) of respondents gave complete responses for reporting their levels of pain before and after a typical day of surgery for all body regions. Analysis showed that for all body areas, there was significantly increased reported pain/discomfort ($p < .01$) from before to after surgery (Table 3). Based on effect size, the increase in reported neck and lower back pain was the largest after a surgical day. The shoulders, hips, and left wrist and hand had the lowest effect size but still showed statistically significant increases in reported pain from prior to after a typical day of surgery.

Table 1. Participant demographics.

Variable		N	%
Sex			
	Male	119	56.1
	Female	93	43.9
Age			
	30–40	31	14.6
	41–50	68	32.1
	51–60	59	27.8
	>60	50	23.6
	No response	4	1.9
Weight (lbs.)			
	110–130	28	13.2
	131–150	38	17.9
	151–170	54	25.4
	171–190	41	19.3
	>190	48	22.6
	No response	3	1.4
Height (in.)			
	59–62	10	4.7
	63–66	59	27.8
	67–70	74	34.9
	71–74	46	21.7
	>74	17	8.0
	No response	6	2.8
Years Performing Surgery			
	1–10	26	12.3
	11–20	71	33.5
	21–30	55	25.9
	>30	59	27.8
	No response	1	0.5
Percent MIS			
	0%	53	25.0
	1–25%	130	61.3
	26–50%	21	9.9
	>50%	7	3.3
	No response	1	0.5

Table 2. Number of participants reporting MSS present by body region.

Body region	Num. reporting MSS	%
Neck	148	74.4
Upper back	106	53.3
Lower back	150	75.4
Right shoulder	57	28.6
Left shoulder	40	20.1
Right wrist/hand	103	51.8
Left wrist/hand	74	37.2
Hips	33	16.6
Knees	74	37.2
Feet/ankles	81	37.2

Table 3. Change in reported pain/discomfort from before to after a typical day of surgery.

Body area	Mean before	Mean after	Mean increase	*r*	*p*
Neck	1.04	2.31	1.27	.67	<.001
Upper back	0.77	1.77	0.99	.58	<.001
Lower back	1.39	2.73	1.34	.71	<.001
Rt. shoulder	0.54	0.86	0.32	.38	<.001
Lt. shoulder	0.37	0.61	0.24	.25	.003
Rt. wrist/hand	0.75	1.29	0.54	.46	<.001
Lt. wrist/hand	0.41	0.72	0.30	.34	<.001
Hips	0.35	0.58	0.23	.30	<.001
Knees	0.72	1.30	0.58	.50	<.001
Feet/ankles	0.66	1.54	0.88	.57	<.001

3.2. Worker factors and post-surgery reported pain

Among worker factors, gender, years performing surgery, age, and weight affected reported pain (Figure 2). For the upper back, women reported 1.19 points higher pain ($p < .001$) than men after surgery. The number of years performing surgery ($\chi^2 = 8.998$, $p < .05$), the respondents' age ($\chi^2 = 8.310$, $p < .05$), and the respondents' weight ($\chi^2 = 11.463$, $p < .05$) affected reported pain and discomfort in the feet and ankles (see Appendix C for regression plots of continuous factors). Respondents who have been performing surgery between 1 and 10 years reported 1.01 and 1.04 points more pain than those performing surgery for 21–30 years ($p < .05$) and those who have been performing surgery for more than 30 years ($p < .05$), respectively. Height did not influence pain and discomfort for any body regions (Appendix A).

3.3. Work factors and post-surgery reported pain

Performing minimally invasive surgery affected post-surgery pain in the upper back ($\chi^2 = 7.819$, $p < .05$), right shoulder ($\chi^2 = 9.182$, $p < .05$), and left shoulder ($\chi^2 = 16.848$, $p < .001$). MIS had an impact on pain reported after surgery where the upper back of people performing MIS for 26–50% of surgeries was 2.11 points higher ($p < .05$) than people performing MIS >50% of the time. For the left shoulder, veterinary surgeons performing MIS for 26–50% of their surgeries reported 0.68 points higher pain than those who perform MIS 0% of the time ($p < .05$) and 0.68 points higher than those who perform MIS 1–25% of the time ($p < .001$).

The pain reported in the left wrist and hand for those performing more than 12 procedures a week was 0.67 points more pain than those performing 5–8 procedures a week ($p < .05$) and 0.80 points more than those performing 9–12 procedures a week ($p < .01$). Differences were also noted in the neck for the area of focus ($\chi^2 = 9.320$, $p < .01$) as shown in Figure 3(a).

Surgeons whose practice focus was solely orthopaedics reported 0.52 points lower pain compared to those whose practice focus was soft tissue ($p < .05$) and 3.5 points lower than those who reported focusing on both soft tissue and orthopaedics ($p < .05$). No statistically significant differences between large and small animal specialties were found for any body region. Similarly, the number of hours performing surgery a week did not affect pain or discomfort (Appendix A).

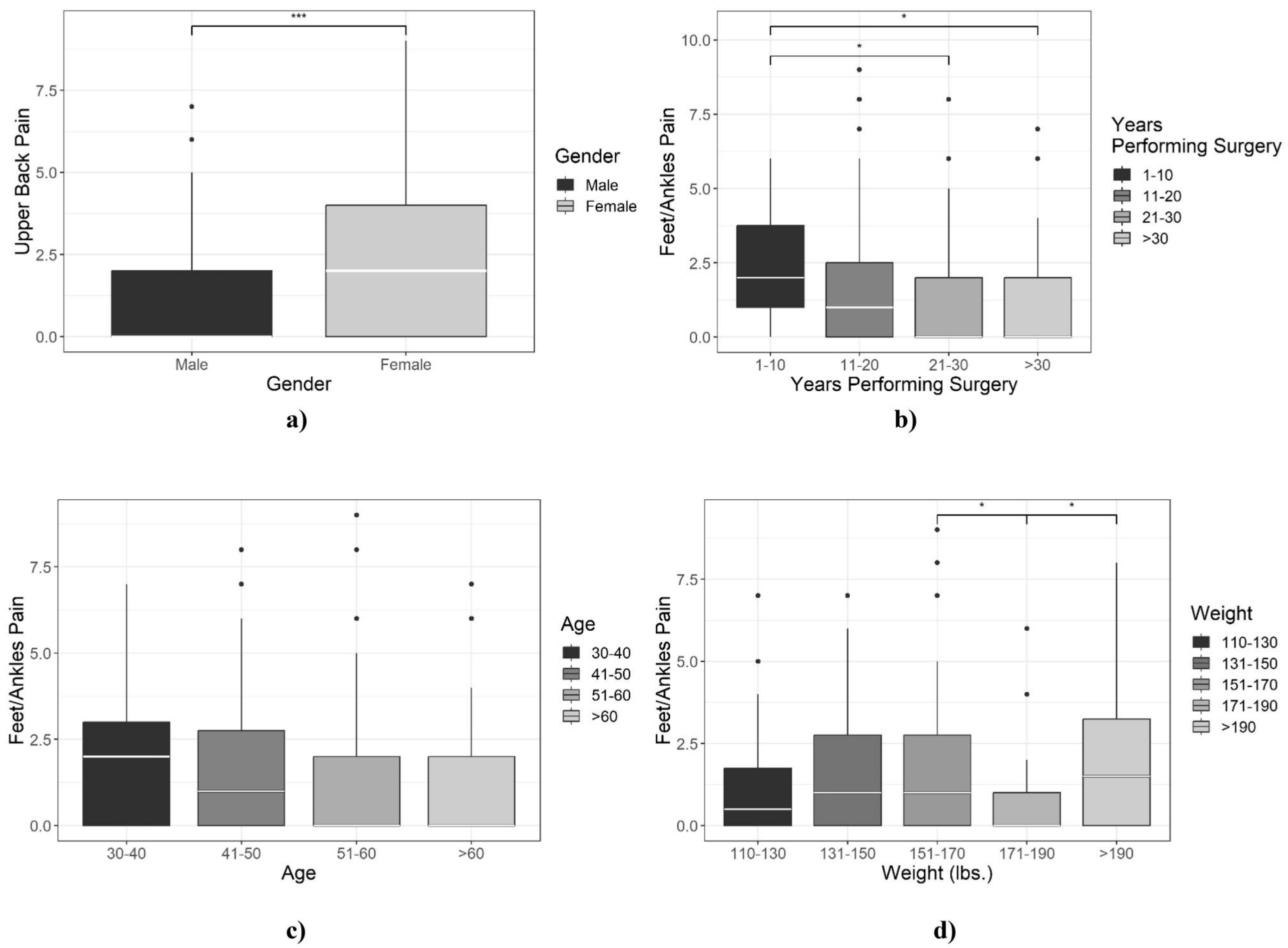

Figure 2. (a) Reported pain/discomfort after surgery for the upper back by gender, (b) reported pain/discomfort post-surgery in the feet/ankles by years performing surgery, (c) reported pain/discomfort post-surgery in the feet/ankles by age group, and (d) reported pain/discomfort post-surgery in the feet/ankles by weight group.

4. Discussion

Findings in this study confirm that musculoskeletal symptoms are a common problem among veterinary surgeons. The majority of respondents reported at least one musculoskeletal symptom in the neck (74%), upper back (53%), lower back (75%), and the right wrist and hand (52%). This is consistent with previous literature on surgeons operating on human patients (Adams et al. 2013; Dalager et al. 2019; Knudsen, Ludewig, and Braman 2014) as well as previous literature on veterinary surgeons (Jones 2020; Smith, Leggat, and Speare 2009). Since the surgical site is lower than the head in veterinary surgery, surgeons commonly have to bend at the neck and maintain this bent position throughout the procedure. Although we did not measure their positions in this study, it is common for veterinary surgeons to move their neck forward to help visualise deeper structures especially in open abdominal and thoracic procedures such as the ovariohysterectomy shown in Figure 1. Coupled with the wide range of patient sizes, this suggests a need for further investigation into the unique challenges presented by veterinary surgeons' workstations. In ergonomic design, the principal focus is ensuring the operator's workstation is built to fit the individual's needs, instead of forcing the individual to adapt to an inadequate workstation. Investigating workstation design in veterinary surgery through an ergonomics lens may be critical in addressing the pervasiveness and severity of MSS in the profession.

In addition to the high relevance of pain, our survey also discovered that the reported pain significantly increased after a surgical day, suggesting that the demands of the surgical workday were perceived as contributing to the reported pain and discomfort across all body regions. It is well-understood that the physical demands of work influence user fatigue and discomfort (Aryal, Ghahramani, and Becerik-Gerber 2017; Darragh et al. 2015; Sluiter et al. 2003), but work demands that require awkward postures, excessive

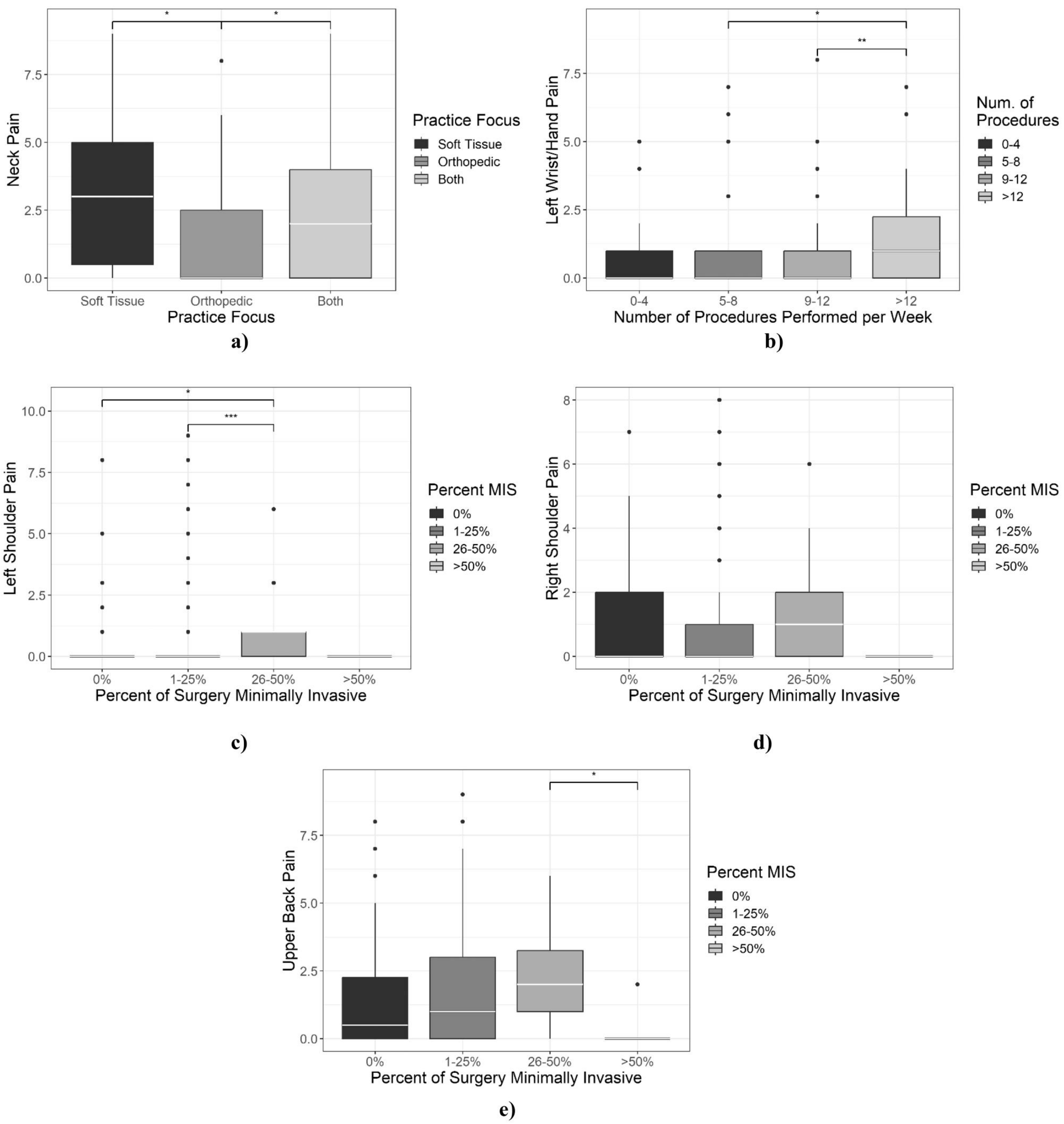

Figure 3. (a) Reported pain/discomfort post-surgery in the neck by practice focus, (b) reported pain/discomfort post-surgery in the left wrist/hand by number of procedures performed per week, (c) reported pain/discomfort post-surgery in the left shoulder by percent of surgery minimally invasive, (d) reported pain/discomfort post-surgery in the right shoulder by percent of surgery minimally invasive, and (e) reported pain/discomfort post-surgery in the upper back by percent of surgery minimally invasive.

force and repetitions, and tasks with long durations are especially associated with musculoskeletal symptoms (da Costa and Vieira 2010; Gallagher and Heberger 2013; Jensen et al. 2002; Josephson et al. 1997; Latko et al. 1999; Nordander et al. 2009). Although statistically significant, our self-reported pain intensity was at the lower end of the pain scale. These prevalent but lower pain intensity results are similar to previous pain survey studies for surgeons (Asadi et al. 2022; Hallbeck et al. 2017; Yu et al. 2017). The low self-reported pain may be partially attributed to workplace culture in both human and veterinary medicine where surgeons have a tendency to prioritise patient care over their own pain and symptoms (Jones 2020; A. Park et al. 2010). Despite these lower reported pain intensities, previous studies reported that many surgeons still resorted to using medication (Bolduc-Bégin et al. 2018; Dalager et al. 2019; Janki et al. 2017; Kim-Fine et al. 2013), seeking treatment such as physical therapy, and taking time away from surgery (Kim et al. 2023; A. E. Park et al. 2017). Therefore, despite reporting low pain intensity, the high prevalence and impact of the pain are strong indicators for a need to control the physical work demands of veterinary surgeon, especially for the neck, back, and hands.

A worker factor that influenced reported pain scores was gender. Previous studies on the relationship between gender and musculoskeletal symptoms in human surgery suggested that women were at higher risks of developing work related musculoskeletal disorders than their male counterparts (Adams et al. 2013; Dalager et al. 2019; Gilkey et al. 2011; Rollman and Lautenbacher 2001; Sutton et al. 2014; Wijnhoven, de Vet, and Picavet 2006). Our survey on veterinary surgeons similarly suggests higher prevalence of reported pain among female surgeons. Unlike general human surgery, the impact of gender may be even greater in the veterinary surgery field. First, female surgeons make up almost half of the survey respondents and professional society member statistics show that females make up 58% of the veterinary surgeon workforce (RCVS 2021). In general surgery, the worker population has been predominantly male with women making up only 26% of the workforce in the United States (US Bureau of Labour Statistics 2022). Second, women may perform more soft-tissue procedures than males (the soft tissue work factor will be further discussed below). However, larger sample sizes may be needed to develop more detailed statistical models to explore these interactions between gender and other work factors.

Another worker factor that influenced musculoskeletal pain was work experience, where surgeons who have been performing surgery for 1–10 years may experience more pain and discomfort in the feet and ankles than those who have been performing surgery for more than 10 years. Similar results were found based on age group, where younger surgeons reported more pain than those who are older. One potential reason for these differences may be due to younger surgeons potentially taking on more cases per week while simultaneously working longer shifts. Another potential explanation for the differences may be due to experience and conditioning. For example, the 'healthy worker' effect (Fox and Collier 1976; Li and Sung 1999; McMichael 1976) describes the phenomenon where healthy workers tend to stay in the workforce, while those who are unhealthy leave (Chowdhury, Shah, and Payal 2017). With this cross-sectional survey being administered only to current members of the ACVS, it is possible that the surgeons who have been performing surgery for many years are the ones who have best figured out how to manage their musculoskeletal pain, while those who were unable to may no longer perform surgery or stay active in professional societies around the topic. Our results also showed that the relationship between experience and symptoms is stronger than the relationship between age and symptoms. This may further point to experience being a more important factor in predicting pain than age itself.

For work factors, one observation is that surgeons whose practice focuses on soft tissue surgery had significantly more reported pain than those focusing on orthopaedic surgery. Soft tissue surgeries often focus on structures in body cavities that constrains the surgeon's body positioning to non-neutral postures for prolonged periods of time (Asadi et al. 2022). Although intraoperative studies observed that high muscle activations were more common in orthopaedic than soft tissue surgery, motion capture data showed that soft tissue procedures required more static positioning (Asadi et al. 2022). These survey results may add evidence to support that static positioning is a key risk factor for worker pain and discomfort during veterinary surgery.

Previous survey studies observed differences in the prevalence of musculoskeletal disorders between veterinarians who focus on large animals and those who focus on small animals (Scuffham et al. 2010). However, the specialty work factor (large vs. small) did not affect self-reported pain in our study. A subtle difference in the studies populations may explain these disparities. Specifically, our study focused on veterinary surgeons while the previous studies focused on general veterinarians. A key difference is that veterinary surgeons typically operate on patients that are under anaesthesia and on an operating room table, while general veterinarians do not. With patients sedated, veterinary surgeons are typically not in situations that expose them to occupational hazards such as bites, scratches, kicks, and trampling that veterinarians are potentially exposed to (Epp and Waldner 2012). Another consideration for this finding is the sample characteristics. Large animal surgeons only represented 18% of survey respondents, while small animal surgeons made up 81% of respondents, and only one respondent selected both. With this imbalance in responses, it is possible we did not capture enough responses to show statistically significant differences in reported pain before and after surgery.

For the work factor minimally invasive surgery, the reported pain in the left shoulder increased as the percent of minimally invasive surgery increased, except in the >50% MIS group. Previous findings have shown that MIS is a risk factor for MSS (Kilkenny et al. 2017; Stucky et al. 2018). The tools and positioning used by surgeons performing minimally invasive surgery put them at a higher risk of MSS than those not performing MIS (Berguer, Forkey, and Smith 1999; Monfared et al. 2022; Vereczkei et al. 2004; Yu et al. 2016). These previous findings would agree with our findings in the left shoulder; however, no increase in pain was observed for the participants that performed MIS >50% of their practice. One possible explanation for this is the low number of respondents who reported performing MIS for >50% of surgeries. Only 3.5% of total respondents that gave responses to the left shoulder question were in the >50% group. For the right shoulder and the upper back, similar results were seen with increasing pain being reported as the percent of MIS increased, except in the MIS >50% group. Although MIS techniques are not as common in veterinary surgery, MIS has already seen significant growth for adoption in human medicine (St. John et al. 2020; Tsui, Klein, and Garabrant 2013). Due to the strong association between MIS and reported pain/discomfort and the potential growth in MIS techniques, there may be a need for prioritising the design of ergonomic techniques and tool controls for surgeons performing MIS procedures.

Finally, the work factor 'number of procedures performed a week' showed that surgeons performing greater than 12 procedures a week reported significantly more pain than those who perform 5–8 procedures a week and those who perform 9–12 procedures a week. This is consistent with Yung et al. who found that injury risk factors for endoscopists included procedure volume and time spent doing endoscopy (Yung et al. 2017). Although our data were categorical, the relationship between the number of procedures and pain was not linear. Specifically, the increase was only significant when the number of procedures was greater than 12. This clear increase at >12 procedures may help provide evidence for establishing a threshold limit value (TLV) for the number of cases performed a week as part of organisational guidelines for minimising musculoskeletal injuries in veterinary surgery.

Although several factors were identified as contributors to worker pain in veterinary surgery, additional studies are needed to address several limitations in the current study design. The work and worker factors addressed in this study are not comprehensive. Additional inquiry into more physical risk factors such as tool selection and workstation design would give further insight into the unique musculoskeletal challenges faced by veterinary surgeons. As this survey was disseminated through the ACVS, responses were only captured for board-certified surgeons who were already working in the field. This limitation leaves out trainees who may be from a younger demographic and less experienced. This is shown by the youngest respondent being 32 years old. Additionally, the survey received a 20.5% response rate. This may suggest a response bias where those who have experienced musculoskeletal symptoms may be more motivated to respond due to its personal relevance.

4.1. Practical applications to veterinary surgeons

Veterinary surgeons reported high rates of MSS associated with performing surgery and were concerned about the longevity of their careers. Common body regions of pain, such as the neck, upper back, and lower back, are commonly affected by poor posture for an extended time for a procedure or multiple procedures. In addition, this study also identifies several key worker and work factors that are influencing pain and discomfort in veterinary surgery. These findings provide evidence that musculoskeletal symptoms are a concern in veterinary surgery and bring awareness to veterinary workers and ergonomists on priority areas for both administrative and engineering controls. This study provides a basis for novel research on the unique occupational health challenges presented by varying patient sizes and the ergonomics of the differing work environments this entails. Through collaboration between veterinary surgeons and expert ergonomists, further research can aid in developing evidence-based organisational guidelines to improve the wellbeing of veterinary surgeons. Further contributions can see the development of ergonomically sound solutions that consider the unique needs and challenges of veterinary surgeons.

Disclosure statement

The authors report there are no competing interests to declare.

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Appendix A. All worker and work factors results for each body region.

		Neck			Upper Back			Lower Back			Right Shoulder			Left Shoulder			Right Wrist/Hand			Left Wrist/Hand			Hips			Knees			Feet/Ankles		
		X^2	p-value	ε^2	X^2	p-value	ε^2	X^2	p-value	ε^2	X^2	p-value	ε^2	X^2	p-value	ε^2	X^2	p-value	ε^2	X^2	p-value	ε^2	X^2	p-value	ε^2	X^2	p-value	ε^2	X^2	p-value	ε^2
Worker Factors																															
Gender		2.456	0.117	0.013	11.125	**< 0.001**	0.060	2.794	0.094	0.014	0.217	0.641	0.001	1.714	0.191	0.010	1.685	0.194	0.010	0.206	0.650	0.001	0.453	0.501	0.003	0.008	0.929	< 0.001	2.977	0.084	0.017
	Male																														
	Female																														
Num. of Years Performing Surgery		3.359	0.339	0.017	3.386	0.336	0.018	3.749	0.290	0.019	0.340	0.952	0.002	2.094	0.553	0.012	5.011	0.171	0.029	5.011	0.171	0.029	2.105	0.551	0.013	4.054	0.256	0.023	8.998	**0.029**	0.052
	1 - 10																														
	11 - 20																														
	21 - 30																														
	>30																														
Age		4.549	0.208	0.024	3.845	0.279	0.021	4.836	0.184	0.025	0.143	0.986	< 0.001	0.337	0.953	0.002	1.374	0.712	0.008	1.304	0.728	0.008	0.963	0.810	0.006	3.918	0.270	0.023	8.310	**0.040**	0.049
	30-40																														
	41-50																														
	51-60																														
	>60																														
Weight		0.822	0.935	0.004	4.788	0.310	0.026	2.597	0.629	0.013	4.675	0.322	0.027	5.330	0.255	0.032	2.171	0.704	0.012	1.309	0.860	0.008	6.245	0.182	0.038	7.004	0.136	0.040	11.463	**0.022**	0.067
	110 - 130																														
	131 - 150																														
	151 - 170																														
	171 - 190																														
	>190																														
Height (in.)		2.372	0.667	0.013	6.520	0.164	0.036	5.723	0.221	0.030	2.384	0.666	0.014	3.463	0.483	0.030	1.880	0.758	0.011	2.751	0.600	0.016	0.876	0.928	0.005	2.860	0.582	0.017	1.125	0.876	0.007
	59 - 62																														
	63 - 66																														
	67 - 70																														
	71 - 74																														
	>74																														
Work Factors																															
Percent Minimally Invasive Surgery		7.015	0.071	0.037	7.819	**0.050**	0.042	6.768	0.080	0.035	9.182	**0.027**	0.052	16.848	**< 0.001**	0.099	2.267	0.519	0.013	2.099	0.552	0.012	3.417	0.332	0.021	5.169	0.160	0.030	1.437	0.697	0.008
	0% MIS																														
	1 - 25% MIS																														
	26 - 50% MIS																														
	>50% MIS																														
Practice Focus		8.765	**0.009**	0.046	2.078	0.354	0.011	2.589	0.274	0.013	1.438	0.487	0.008	0.609	0.737	0.004	0.020	0.990	< 0.001	0.077	0.962	< 0.001	2.408	0.300	0.015	2.406	0.300	0.014	2.349	0.309	0.014
	Soft Tissue Surgery																														
	Orthopedic Surgery																														
	Both																														
Specialty		4.103	0.129	0.021	2.726	0.255	0.015	3.149	0.207	0.016	0.204	0.903	0.001	5.254	0.072	0.031	3.093	0.213	0.018	3.611	0.164	0.021	1.705	0.426	0.010	1.482	0.476	0.008	0.582	0.747	0.003
	Large Animal																														
	Small Animal																														
	Other/Both																														
Number of Procedures Performed per Week		1.328	0.723	0.007	3.089	0.378	0.018	2.707	0.439	0.015	1.751	0.626	0.011	0.453	0.929	0.003	5.156	0.161	0.031	12.154	**0.007**	0.074	0.435	0.933	0.003	3.928	0.269	0.024	1.329	0.722	0.008
	0 - 4																														
	5 - 8																														
	9 - 12																														
	>12																														
Hours Performing Surgery a Week		0.410	0.995	0.002	1.752	0.882	0.010	3.263	0.660	0.018	6.274	0.280	0.038	3.219	0.666	0.020	5.423	0.366	0.033	6.642	0.249	0.040	2.011	0.847	0.013	3.510	0.622	0.021	2.298	0.807	0.014
	0 - 5.0																														
	5.1 - 10.0																														
	10.1 - 15.0																														
	15.1 - 20.0																														
	20.1 - 25.0																														
	>25																														

Appendix B. Survey sample

Number of years performing surgery (Start with Year1 of residency)	◯ 1-5 years ◯ 6-10 years ◯ 11-15 years ◯ 16-20 years ◯ 21-30 years ◯ 31-35 years ◯ 35+ years
Specialty	☐ Small animal surgery ☐ Large animal surgery ☐ Other
Surgical Subspecialty of focus	☐ Soft tissue surgery ☐ Orthopedic surgery ☐ Both soft tissue and orthopedic surgery ☐ Other

How much time do you perform surgery in a typical week (Hours Per Week)?	____________________
How many surgical procedures did you do in a typical week?	____________________
Percent of practice consisting of minimally-invasive surgeries (MIS), e.g., endoscopic, laparoscopic, fracture repair, etc.	◯ 0% ◯ 1-25% ◯ 26-50% ◯ >50%

What is your Pain/Discomfort PRIOR to a typical surgery day? (Please rate each region)

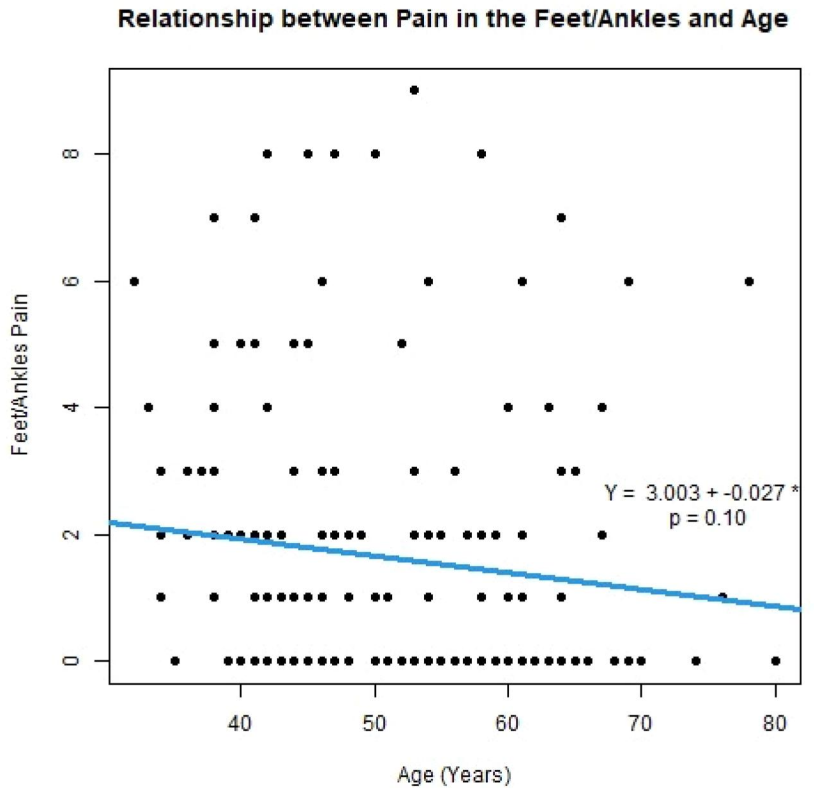
	(No pain) 0	1	2	3	4	5	6	7	8	9	(Worst possible) 10
Neck	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Upper Back	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Lower Back	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Right Shoulder	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Left Shoulder	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Right Wrist/Hand	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Left Wrist/Hand	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Hips	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Knees	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Feet/Ankles	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

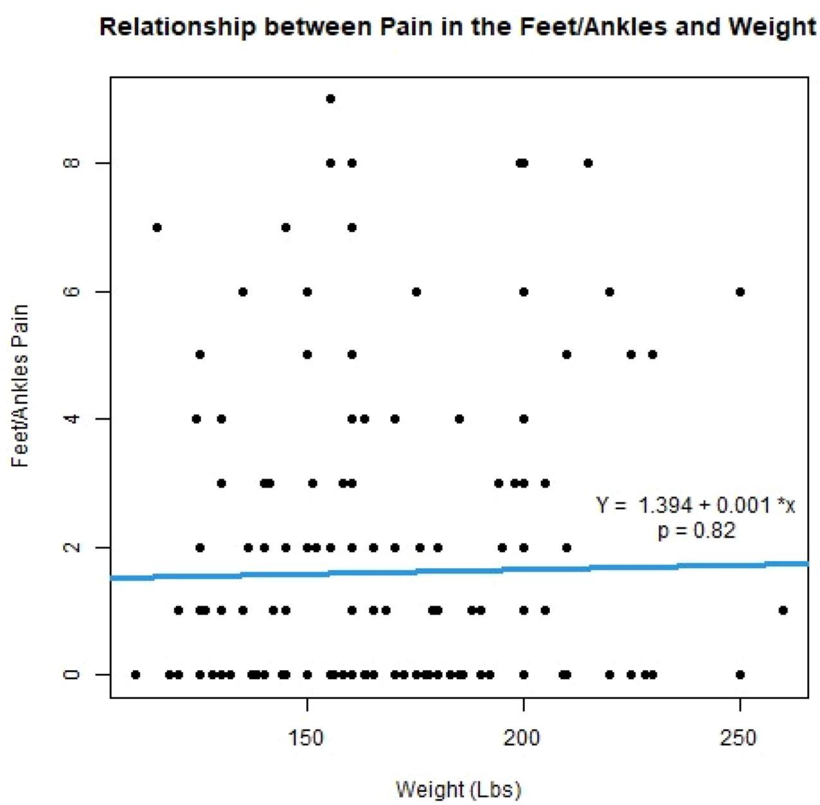
What is your Pain/Discomfort AFTER a typical surgery day? (Please rate each region)

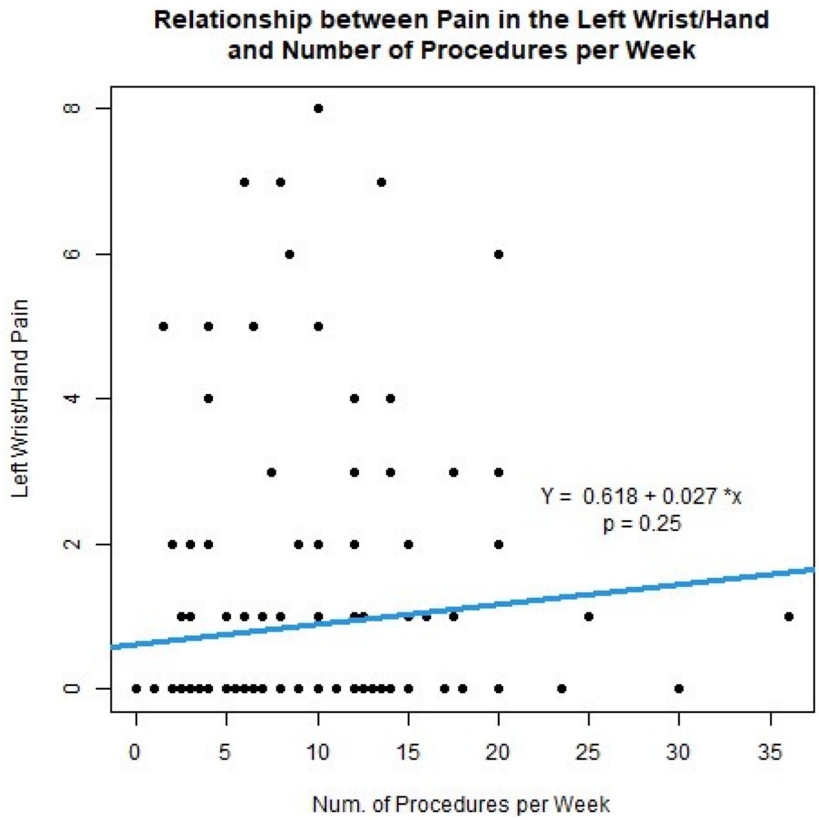
	(No pain) 0	1	2	3	4	5	6	7	8	9	(Worst possible) 10
Neck	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Upper Back	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Lower Back	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Right Shoulder	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Left Shoulder	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Right Wrist/Hand	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Left Wrist/Hand	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Hips	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Knees	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Feet/Ankles	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Demographics	
Gender	◯ Male ◯ Female
Age	______________________________
Weight (lbs)	______________________________
Height (inches)	______________________________
Species you work with (Check all that applies)	☐ Dog ☐ Cat ☐ Horse ☐ Cow ☐ Sheep ☐ Goat ☐ Llama ☐ Other

Appendix C. Regression plots for continuous significant factors.






Relationship between Pain in the Left Wrist/Hand
and Number of Procedures per Week
Left Wrist/Hand Pain
Num. of Procedures per Week
Y = 0.618 + 0.027 *x
p = 0.25
0
2
4
6
8
0
5
10
15
20
25
30
35