Work-Related Musculoskeletal Injuries in Plastic Surgeons in the United States, Canada, and Norway

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Background: Musculoskeletal injuries are more common among surgeons than among the general population. However, little is known about these types of injuries among plastic surgeons specifically. The authors' goals were to evaluate the prevalence, nature, causes, and potential solutions of these musculoskeletal injuries among plastic surgeons in three different countries: the United States, Canada, and Norway.

Methods: A survey was e-mailed to plastic surgeons in the United States, Canada, and Norway, soliciting their demographics, practice description, history of musculoskeletal issues, potential causes of these symptoms, and proposed suggestions to address these injuries. The prevalence of various musculoskeletal symptoms was calculated, and predictors of these symptoms were evaluated using multivariate logistic regression.

Results: The survey was sent to 3314 plastic surgeons, with 865 responses (response rate, 26.1 percent); 78.3 percent of plastic surgeons had musculoskeletal symptoms, most commonly in the neck, shoulders, and lower back. U.S. surgeons were significantly more likely to have musculoskeletal symptoms than Norwegian surgeons (79.5 percent versus 69.3 percent; $p < 0.05$); 6.7 percent of all respondents required surgical intervention for their symptoms. The most common causative factors were long surgery duration, tissue retraction, and prolonged neck flexion. The most common solutions cited were core-strengthening exercises, stretching exercises, and frequent adjustment of table height during surgery.

Conclusions: Plastic surgeons are at high risk for work-related musculoskeletal injuries. Ergonomic principles can be applied in the operating room to decrease the incidence and severity of those injuries, and to avoid downstream sequelae, including the need for surgery. (*Plast. Reconstr. Surg.* 141: 165e, 2018.)

Surgeons brave long training, arduous work hours, and high stress levels to improve their patients' lives. In the process, they often neglect their own physical and mental health. Indeed, there is growing recognition that surgeons must address their own health if they wish to be effective healers of others,[1] and that physician well-being is essential for satisfactory patient outcomes.[2]

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Painful musculoskeletal conditions are particularly common among surgeons. Studies have estimated that 60[3,4] to 90 percent[5] of all surgeons suffer from pain and stiffness in their neck, back, or shoulders.[6] Among urologists, a dose-response relationship has been demonstrated between surgical volume/case length and severity of musculoskeletal symptoms.[7]

Plastic surgeons are at particularly high risk of developing musculoskeletal symptoms. One

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study found that among various surgical specialties, plastic surgeons had the highest likelihood of having musculoskeletal pain.[8] Ninety-four percent of plastic surgeons experienced musculoskeletal pain regularly, and in 27 percent of those cases, the pain occurred during or after microscope use.

Little has been written about the nature, prevalence, causes, and potential solutions of musculoskeletal symptoms in plastic surgeons. The impact of work-life balance on musculoskeletal symptoms has also not been well studied. It is well known that the Scandinavian health care system places more emphasis on work-life balance compared with North American health care systems.[9,10] The effects of this enhanced work-life balance on physical health are unclear.

Our purposes with this study were to evaluate the prevalence and nature of musculoskeletal injuries in plastic surgeons in the United States, Canada, and Norway; to pinpoint specific factors and behaviors that may lead to those symptoms; and to suggest potential solutions. Our hypothesis was that musculoskeletal injuries among U.S. and Canadian plastic surgeons would be more common than among Norwegian counterparts, in part because of systemic, social, and cultural health care differences.

METHODS

After approval by the institutional review board at our institution, a survey was sent by e-mail to members of the American Society of Plastic Surgeons, the Norwegian Association of Plastic Surgeons, and the Canadian Society of Plastic Surgeons. The entire memberships of the Norwegian Association of Plastic Surgeons and the Canadian Society of Plastic Surgeons were surveyed. For the American Society of Plastic Surgeons, the Society sent the survey to approximately one-third of the membership whose characteristics were statistically representative of the membership as a whole. This is because of the American Society of Plastic Surgeons' policy to not send surveys to the entire membership, to avoid survey fatigue among members. The survey collected information related to basic demographics, job description, and history of musculoskeletal symptoms (Table 1).

The demographics of the three populations of surgeons were compared using analysis of variance. Univariate analyses of predictors of musculoskeletal symptoms were performed using the chi-square test. Binary logistic regression was used to perform multivariate analysis of the predictors of musculoskeletal symptoms.

RESULTS

The survey was sent to 3314 plastic surgeons. This included 2651 members of the American Society of Plastic Surgeons (a statistically representative sample of the entire American Society of Plastic Surgeons membership), 216 members of the Norwegian Association of Plastic Surgeons, and 447 members of the Canadian Society of Plastic Surgeons. Eight hundred sixty-five plastic surgeons responded, for an overall response rate of 26.1 percent (23.9 percent in the United States, 34.7 percent in Norway, and 34.9 percent in Canada).

The three populations were mostly similar, but more U.S. surgeons practiced cosmetic surgery, and more Canadian and Norwegian surgeons practiced microsurgery (Table 2). Hand was the dominant specialty among Canadian surgeons, who also tended to perform the highest yearly number of surgical procedures.

Overall, 78.3 percent of all respondents had work-related musculoskeletal symptoms, with a significantly higher prevalence in U.S. surgeons than in Norwegian surgeons (Table 3). The most common symptom was pain, followed by stiffness, fatigue, and numbness; 7.3 percent of surgeons had to decrease their workload over the long term because of their symptoms, and 9.7 percent had to take time off specifically because of job-related musculoskeletal injuries (average of 43.9 days total over their career). The most common locations of the symptoms were the neck, shoulders, and lower back. Symptoms most often manifested late (several hours) after surgery, but 13.6 percent of respondents with symptoms had chronic, persistent symptoms. Surgeons felt that the procedures most likely to trigger or exacerbate their symptoms were microsurgery, augmentation mammaplasty, and suction lipectomy. The most common factors or maneuvers implicated in their symptoms were long surgery duration, retraction of tissues, and prolonged neck flexion.

Also, 6.7 percent of respondents required surgery to treat their symptoms. The most common operations required were spinal fusion/diskectomy, carpal tunnel release, and hand surgery (most commonly arthroplasty). When asked about solutions or techniques that they had used to improve their symptoms, respondents most commonly cited core-strengthening exercises, stretching exercises, and adjusting the table height frequently during surgery.

Musculoskeletal symptoms were most prevalent among U.S. plastic surgeons (p = 0.04

Table 1. Questionnaire Sent to Plastic Surgeons in the Three Regions

1. What is your age range?
   a. <35 yr
   b. 35–44 yr
   c. 45–54 yr
   d. 55–64 yr
   e. ≥65 yr
2. What is your gender?
   a. Male
   b. Female
3. What is your practice type?
   a. Solo private practice
   b. Group private practice
   c. Hospital-employed
   d. Academic
4. Which of the following most closely approximates your practice distribution?
   a. 100% cosmetic
   b. 75% cosmetic, 25% reconstructive
   c. 50% cosmetic, 50% reconstructive
   d. 25% cosmetic, 75% reconstructive
   e. 100% reconstructive
5. What is your dominant hand?
   a. Right
   b. Left
   c. Both
6. What is your glove size?
   a. 5.5
   b. 6
   c. 6.5
   d. 7
   e. 7.5
   f. 8
   g. 8.5
   h. 9
7. What is your main area of specialization? (Check all that apply)
   a. Microsurgery
   b. Adult craniofacial
   c. Pediatric craniofacial
   d. Aesthetic
   e. General reconstructive
   f. Hand surgery
   g. Burn surgery
   h. Breast reconstruction
8. How many surgical cases do you perform every year?
   a. <100
   b. 100–300
   c. 300–600
   d. >600
9. Have you ever sustained a musculoskeletal injury *directly related to your job as a surgeon?*
   a. Yes
   b. No
10. If you answered yes to question 9, please describe the injury, and the circumstances under which it may have occurred.
11. If you answered yes to question 9, has this injury caused you to decrease your surgical workload?
    a. Yes (if so, how much in percent?)
    b. No
12. If you answered yes to question 9, have you ever had to take time off work because of this injury?
    a. Yes (if so, how long?)
    b. No
13. If you answered yes to question 9, have you ever had to have surgery for this injury?
    a. Yes (if so, how many and what kind of surgery?)
    b. No
14. Have you ever had any physical discomfort or symptoms *you would attribute to your job as a surgeon?*
    a. Yes
    b. No
15. If you answered yes to question 14, which of the following apply? (Check all that apply)
    a. Numbness
    b. Stiffness
    c. Fatigue
    d. Pain
    e. Other

(*Continued*)

Table 1. ***Continued***

16. If you answered yes to question 14, which body parts are most commonly affected? (Check all that apply)
    a. Head
    b. Neck
    c. Shoulders
    d. Upper back
    e. Mid back
    f. Lower back
    g. Upper extremities
    h. Hands
    i. Lower extremities
    j. Feet
    k. Other
17. If you answered yes to question 14, when do these symptoms or discomforts bother you?
    a. During surgery
    b. Immediately after surgery
    c. Later after surgery (starts hours or days later)
    d. Persistently
18. If you answered yes to question 14, performing what surgical procedure(s) is most likely to cause your symptoms? (Open field for comment)
19. If you answered yes to question 14, what measures have you taken to minimize these problems or conditions? (Check all that apply)
    a. None
    b. Avoidance of exacerbating activity (please describe how) (Open field for comment)
    c. Modification of work environment (please describe how) (Open field for comment)
    d. Physiotherapy
    e. Exercise (please describe) (Open field for comment)
    f. Other
20. What advice would you offer other plastic surgeons who hope to avoid job-related musculoskeletal injuries? (Open field for comment)

compared with Norwegian surgeons), those in the 45- to 54-year age group ($p = 0.006$ compared to those aged 35 to 44 years; $p = 0.007$ compared to those aged 65 years and older), female surgeons ($p = 0.009$ compared to male surgeons), those with a 100 percent cosmetic practice ($p = 0.03$ compared to those with a 50 percent cosmetic, 50 percent reconstructive practice), and those with glove size 6 ($p = 0.03$ compared to glove size 8.5) (Table 4). The main protective factor was performing fewer than 100 surgical cases per year ($p < 0.01$ compared to 100 to 300, 301 to 600, and >600 cases).

Multivariate regression analysis of potential predictors of musculoskeletal symptoms demonstrated the risk factors for musculoskeletal symptoms in each body area (Table 5). Female gender was a risk factor for symptoms in the head, shoulders, upper back, hands, and feet. Specializing in microsurgery was a risk factor for symptoms in the shoulders and upper back, whereas specializing in aesthetic surgery was a risk factor for symptoms in the head, and specializing in adult craniofacial surgery was a risk factor for symptoms in the lower extremities and feet. Specializing in hand surgery was protective from shoulder and mid-back symptoms. Surgeons with smaller glove sizes were more likely to have musculoskeletal symptoms in their hands.

DISCUSSION

This study was undertaken because of prior research showing that plastic surgeons have the highest risk of musculoskeletal symptoms of any surgical specialty.[8] Our study confirms that musculoskeletal symptoms are very common among plastic surgeons in the United States, Canada, and Norway. Indeed, we found that neck pain is much more common among plastic surgeons (52.1 percent) than literature reports on the general population (17.9 percent),[11] computer users (23.2 percent),[12] and even forestry workers exposed to heavy loads and vigorous vibration (20 percent).[13]

Norwegian surgeons appear to be at somewhat lower risk than Americans and Canadians. The greater emphasis on work-life balance in Scandinavia is a well-known phenomenon.[9,10] It is unclear, however, whether that plays a role in the lower rate of musculoskeletal symptoms among Norwegian plastic surgeons. It is worth noting that Norwegian surgeons in our study tended to perform more reconstructive surgery than cosmetic surgery, and that microsurgery, a high-risk specialty for musculoskeletal symptoms, was especially prominent in Norway. The fact that Norwegian surgeons are able to perform high volumes of microsurgery yet have the lowest rates of musculoskeletal symptoms is remarkable, and begs further investigation. An observation by one of

Table 2. Demographic and Occupational Details of the Plastic Surgeons in the Study

	Overall	United States	Norway	Canada
Total no. surveyed	3314	2651	216	447
No. of respondents	865	634	75	156
Response rate	26.1%	23.9%	34.7%	34.9%
Gender				
Male	75.8%	77.6%	64%[a],,[c]	74.4%
Female	24.2%	22.4%	36%[a],,[c]	25.6%
Practice setting				
Academic	23.4%	19.6%[c]	28%	37.8%
Small group	18.6%	18.6%	21.3%	17.3%
Shared facility	4.9%	5.4%	2.7%	3.8%
Medium group	2.7%	2.1%	12%[c]	0.6%
Solo	35.1%	39.6%	5.3%[a],,[c]	31.4%
Large multispecialty	8.7%	10.1%	13.3%	0.6%[a],,[b]
Large plastic surgery	5.8%	3.9%[b],,[c]	17.3%	8.3%
Military	0.6%	0.8%	0	0
Practice mix				
100% cosmetic, 0% reconstructive	13.1%	14.2%	12%	9%
75% cosmetic, 25% reconstructive	15.5%	17.7%[c]	16%	6.4%[a]
50% cosmetic, 50% reconstructive	17.9%	21%[b],,[c]	6.7%	10.9%[a]
25% cosmetic, 75% reconstructive	31.2%	31.1%[b]	18.7%[a],,[c]	37.8%[b]
0% cosmetic, 100% reconstructive	22.2%	15.9%[b],,[c]	46.7%[a]	35.9%[a]
Handedness				
Right	93.8%	95.6%[b],,[c]	86.7%	89.7%
Left	4.4%	2.5%	10.7%	9%
Both	1.8%	1.9%	2.7%	1.3%
Main specialty (may choose more than one)				
Microsurgery	22.3%	18.6%	34.7%[a]	31.4%[a]
Adult craniofacial	5.9%	6%	6.7%	5.1%
Pediatric craniofacial	8.3%	8.2%	4%	10.9%
Aesthetic	51.7%	56.6%	37.3%[a]	38.5%[a]
General reconstruction	44.4%	45.7%	53.3%	34.6%[a],,[b]
Hand	25.7%	20.3%	17.3%	51.3%[a],,[b]
Burn	5.2%	2.5%	21.3%[a],,[c]	8.3%
Breast	38.7%	38.8%	48%[c]	34%
Annual surgical cases				
<100	4.4%	4.9%	4%	2.6%
100–300	40.6%	42.9%[c]	41.3%	30.8%
300–600	38.4%	39.4%	41.3%	32.7%
>600	15.1%	11.5%	9.3%	32.7%[a],,[b]

[a]Statistically different from the United States.
[b]Statistically different from Norway.
[c]Statistically different from Canada.

the authors (T.S.W.) who has practiced in both the United States and Norway is that Norwegian microsurgeons usually take a break for lunch before performing the microsurgical anastomosis, thus allowing for a break before using the microscope. In addition, Norwegians culturally typically have longer vacations than North Americans, and this may provide an opportunity for rest and recovery from work-related musculoskeletal symptoms. Another factor that may contribute to regional differences includes shorter length of surgery days in countries with socialized medicine such as Norway and Canada, and a more active lifestyle among Norwegian surgeons. It should be noted, however, that these cultural differences among surgeons have not been studied, and therefore this is conceptual and theoretical at this time.

Etymologically, the term ergonomics means "natural laws of work."[12] The aim of the field of ergonomics is to modify the work environment to fit it to the worker.[14–16] The field of ergonomics is most commonly used to study desk and factory workers, but lessons learned from those fields can be readily applied to surgeons. For example, in a factory, the instrument should be made to fit the worker's hand size. In the operating room, size mismatch between the surgeon's hand and their instrument is a readily observed but underrecognized ergonomic error, which may account for the high prevalence of hand musculoskeletal symptoms among female surgeons, and surgeons with smaller hands.

However, there are numerous other ergonomic errors that occur in the operating room that are less readily noticed. Among desk and factory workers, the National Institute of Occupational Safety and Health reported several common ergonomic errors that lead to musculoskeletal

Table 3. Work-Related Musculoskeletal Symptoms in Plastic Surgeons*

	Overall	United States	Norway	Canada
Respondents	865	634	75	156
Injury/discomfort related to job	78.3%	79.5%[b]	69.3%[a]	77.6%
Type of symptoms (may choose more than one)				
Pain	80.8%	81%	80.8%	80.2%
Stiffness	63.5%	64.3%	69.2%	57.9%
Fatigue	53.3%	54.2%	53.8%	49.6%
Numbness	29.7%	31.2%	23.1%	26.4%
Decreased workload because of symptoms	7.3%	6.9%	8%	8.3%
Average % decrease in workload	27%	26%	38%	25%
Time off becasue of symptoms	9.7%	9.6%	9.3%	10.3%
Average time off (days)	43.9	45.3	32.6	43.6
Surgery required	6.7%	7.1%	2.7%	7.1%
Spinal fusion/discectomy	3.8%	4.4%	1.9%	2.5%
Carpal tunnel release	2.1%	2%	2%	2.5%
Hand surgery	1%	0.8%	0	2.5%
Shoulder surgery	1%	1.2%	0	0.8%
Elbow surgery	0.3%	0.2%	0	0.8%
Hernia repair	0.1%	0.2%	0	0
Hip surgery	0.1%	0.2%	0	0
Body parts affected (may choose more than one)				
Neck	66.6%	66.3%	63.5%	69.4%
Shoulders	52%	52%	61.5%	47.9%
Lower back	39.9%	40.1%	44.2%	37.2%
Upper back	38.7%	38.7%	34.6%	40.5%
Hands	38.3%	40.5%	25%	34.7%
Upper extremities	18.2%	18.1%	17.3%	19%
Mid back	16.2%	16.1%	19.2%	15.7%
Feet	13.3%	14.1%	5.8%	13.2%
Lower extremities	11.8%	12.3%	13.5%	9.1%
Head	6.1%	5%	11.5%	8.3%
Timing of symptoms (may choose more than one)				
During surgery	19.8%	19.6%	19.2%	20.7%
Immediately after surgery	24.8%	25.8%	21.2%	22.3%
Later after surgery	39.1%	39.1%	36.5%	40.5%
Persistently	13.6%	12.7%[b]	23.1%[a]	13.2%
Exacerbating procedures (may choose more than one)				
Microsurgery	24.4%	23.8%	19.2%	28.9%
Augmentation mammaplasty	11.8%	11.9%	3.8%	14.9%
Suction lipectomy	11.4%	12.1%	5.8%	10.7%
Abdominoplasty	9.7%	9.7%	11.5%	9.1%
Reduction mammaplasty	9.3%	10.3%	7.7%	5.8%
Rhytidectomy	7.8%	9.3%	1.9%	4.1%
Cleft palatoplasty	6.2%	6.2%	1.9%	8.3%
Body contouring	4.4%	5.2%	1.9%	2.5%
Injectables	0.6%	0.8%	0	0
Exacerbating factors (may choose more than one)				
Surgery longer than 3 hr	37.1%	36.5%	38.5%	38.8%
Retraction	13.9%	13.9%	7.7%	16.5%
Prolonged neck flexion	8.6%	8.5%	1.9%[c]	11.6%[b]
Loupes	3.2%	1.8%	3.8%	9.1%
Headlight	1.6%	1.8%	0	1.7%
Measures to minimize symptoms (may choose more than one)				
Core-strengthening exercises	27.2%	26.8%	32.7%	26.4%
None	22.3%	23%	15.4%	22.3%
Stretching	14.9%	16.9%[b]	3.8%[a]	11.6%
Adjust table height frequently	9.7%	11.1%	3.8%	6.6%
Change position frequently	5.8%	6%	5.8%	5%
Sit during surgery	5%	5.5%	1.9%	4.1%
Avoid long cases	4.6%	5%	1.9%	4.1%
Use assistant for retraction	4.3%	4.8%	1.9%	3.3%
Padded floor mats	4%	4.6%	0	3.3%
Compression stockings	1.5%	1.6%	0	1.7%

*The percentages shown are relative to the number of respondents with injury/discomfort related to their job.
[a]Statistically different from the United States.
[b]Statistically different from Norway.
[c]Statistically different from Canada.

symptoms, including static/fixed postures, leaning forward or to the side, forward head position, shoulder abduction, and neck flexion.[3] Interestingly, one study analyzed surgeon posture, and found three very similar errors likely to result in musculoskeletal injuries, as follows[17]:

1. *Forward head position*: Surgeons often unconsciously drift their heads forward, lengthening the moment arm of the head on the neck and increasing the effective weight of the head by 10 pounds for every inch that the head moves forward.[15] This leads to accelerated degenerative changes in the midcervical spine. The amount of load on the cervical spine is greatly magnified by heavy headlights.[18] There is also often concern that loupes may cause neck pain; however, this has been studied extensively in dentists and dental hygienists, with no clear evidence that modern lightweight loupes increase neck discomfort (although small, 2.5× loupes were used in the study for short periods, which may not be generalizable to plastic surgeons).[19] In contrast, prismatic loupes, which allow the surgeon to work without flexing their neck, have been thought to theoretically improve neck pain. However, studies have not demonstrated decreased neck discomfort with those loupes.[20]
2. *Sustained and improper shoulder elevation and internal rotation*: This causes fatigue to the deltoid and trapezius muscles. This error is most commonly observed when the operating table is too high compared to the surgeon's height.
3. *Pelvic girdle asymmetry*: An example of this is placing most of one's weight on one foot, which causes asymmetrical loading, and back and leg pain. This error is most commonly observed when the surgeons are reaching across the patient to the contralateral side, or when the surgeons are twisting their body to align their visual field with the longitudinal axis of the patient's body (such as when dissecting the superior subcutaneous tunnel in an abdominoplasty).

With these ergonomic errors in mind, and given the results of our survey, we can begin by outlining two major steps that surgeons can take in the operating room to reduce their risk of musculoskeletal injury:

1. *Setting up the operating room to fit them ergonomically*: Just as surgeons vigilantly verify patient positioning and padding before starting surgery, they should adapt the operating room to their body before making an incision.[21] When the operating table is too low, the surgeons will need to flex their necks and place their heads in a forward position, leading to neck pain. When the operating table is too high, they will compensate with shoulder abduction, leading to deltoid and trapezius strain.[22] When arm boards are placed at 90 degrees to the body, the surgeons may need to twist their trunks awkwardly to work around the boards, leading to pelvic girdle asymmetry and low back pain.
2. *Being constantly aware of their posture during surgery, and making frequent adjustments*: Surgeons who are more aware of their posture, and who make frequent adjustments to bed height and to their posture, are less likely to suffer from musculoskeletal pain than surgeons who do not.[23] Static positioning has been shown to increase the risk of neck pain in office workers.[24] Sustained neck flexion increases the risk of chronic upper trapezius strain and neck pain two-fold.[25] This is particularly prevalent in dental professionals.[20] The upper trapezius strain has been demonstrated myoelectrically in workers with chronic neck pain, along with decreased myoelectric activity in the neck erector muscles.[26] High static loads lead to muscle fatigue and ischemia.[27–30] Microbreaks lasting 30 seconds every 30 to 40 minutes, during which the muscles that have been subjected to static load are moved and stretched, have been shown to decrease the risk of musculoskeletal injuries.[31]

In addition, surgeons can also take steps outside the operating room to mitigate musculoskeletal symptoms. Frequent stretching of the paraspinous musculature decreases the incidence of neck discomfort.[32] Strength training of the neck erector muscles decreases discomfort in women with chronic neck pain.[33] Core-strengthening exercises have been shown, in multiple randomized controlled trials, to reduce low back pain.[34–36] The mechanism of action of core-strengthening exercises is multifactorial, and includes stabilization of the spine, improvement of blood flow to the intervertebral disks, and improvement of mood, thereby decreasing pain perception.[37] Our survey findings are in full agreement with the

Table 4. Univariate Analysis of Risk Factors for Musculoskeletal Symptoms Related to Plastic Surgery

Factor	Proportion with Injury/ Discomfort Related to Job	*p*
Country		
United States	79.5%	0.04 (compared to Norway)
Norway	69.3%	
Canada	77.6%	
Age		
<35 yr	73.3%	
35–44 yr	75.5%	
45–54 yr	85%	<0.01 (compared to 35–44 and >65 yr)
55–64 yr	78.6%	
≥65 yr	68.2%	
Gender		
Male	76.2%	
Female	84.9%	0.01
Practice setting		
Academic	78.7%	
Small group	77%	
Shared facility	78.6%	
Medium group	87%	
Solo	79.3%	
Large multispecialty	78.7%	
Large plastic surgery	74.5%	
Military	60%	
Practice mix		
100% cosmetic, 0% reconstructive	85%	0.03 (compared to 50% cosmetic, 50% reconstructive)
75% cosmetic, 25% reconstructive	77.6%	
50% cosmetic, 50% reconstructive	74.2%	
25% cosmetic, 75% reconstructive	80.4%	
0% cosmetic, 100% reconstructive	75.5%	
Hand dominance		
Right	78.8%	
Left	83.9%	
Both	81.3%	
Glove size		
5.5	33.3%	
6	89.7%	0.03 (compared to 8.5)
6.5	84.5%	
7	77.1%	
7.5	79.1%	
8	77.6%	
8.5	71.4%	
9	80%	
Main specialty		
Microsurgery	81.3%	
Adult craniofacial	86.3%	
Pediatric craniofacial	83.3%	
Aesthetic	80.1%	
General reconstructive	77.9%	
Hand	75.7%	
Burn	80%	
Breast	82.1%	
Annual surgical cases		
<100	60.5%	0.01 (compared to 100–300, 301–600, >600)
100–300	79.5%	
301–600	80.1%	
>600	81.7%	

literature: core strengthening and stretching were the two most commonly cited recommendations among the surgeons in our survey.

One of our survey findings, which has previously been demonstrated among laparoscopic surgeons,[38] is the increased risk of musculoskeletal symptoms in the hand among surgeons with smaller hands. Surgical instruments are not customized to the surgeon's hand size, and repetitive use of oversized instruments places undue strain on hand joints. One percent of surgeons in our survey reported having required steroid injections or arthroplasty for the treatment of carpometacarpal joint arthritis; 3.3 percent of surgeons reported having had carpal tunnel syndrome, and 68.2 percent of these surgeons were female

Table 5. Multivariate Analysis of Predictors of Musculoskeletal Symptoms Related to Plastic Surgery

Predictors of Musculoskeletal Symptoms	OR (95% CI)	*p*
Head symptoms		
Female	2.28 (1.15–4.56)	0.02
Aesthetic specialty	2.94 (1.14–7.7)	0.03
Neck symptoms		
None		
Shoulder symptoms		
Female	2.15 (1.54–3.01)	<0.001
Microsurgery specialty	1.47 (1.01–2.13)	0.05
Hand specialty	0.64 (0.44–0.93)	0.02
Upper back symptoms		
Female	1.92 (1.37–2.78)	<0.001
Microsurgery specialty	1.64 (1.1–2.4)	0.01
Mid-back symptoms		
Hand specialty	0.5 (0.29–0.88)	0.01
Lower back symptoms		
None		
Upper extremity symptoms		
None		
Hand symptoms		
Female	1.5 (1.05–2.13)	0.03
Small glove size*		0.001
Lower extremity symptoms		
Adult craniofacial specialty	4 (1.73–9.27)	0.002
Foot symptoms		
Female	1.85 (1.1–3)	0.02
Adult craniofacial specialty	3.16 (1.33–7.5)	0.01

*No odds ratio because it is a continuous variable.

(compared with 24.2 percent female surgeons in our overall sample). In addition to repetitive motion, another potential risk factor for carpal tunnel syndrome is vibratory exposure.[13] Plastic surgeons who perform suction lipectomy are therefore at high risk for carpal tunnel syndrome, especially when power-assisted liposuction is used. The noxious effects of vibration are thought to result from the tonic vibration reflex: as a reflexive response to the vibration, both agonistic and antagonistic muscles contract at high frequency to counteract the vibratory motion and stabilize the upper extremity.[39] It should be noted, however, that the relationship between vibration and carpal tunnel syndrome is not proven.[40] In our study, we did not find liposuction to be a risk factor for carpal tunnel syndrome.

We found that, overall, female surgeons were at higher risk for musculoskeletal injuries. This has been previously demonstrated by a study on pediatric otolaryngologists, which found that women were more likely to have musculoskeletal symptoms than men.[3] Indeed, a recent survey of American Society of Plastic Surgeons members found that 51 percent of female surgeons were "often exhausted."[41] This was not simply because of mismatch between female surgeon hand size and instrument size, as both gender and hand size were found to be independent predictors of increased musculoskeletal symptoms. The cause of increased musculoskeletal symptoms in female plastic surgeons is unknown.

Musculoskeletal symptoms in desk and factory workers progress through three chronologic phases.[42,43] Early symptoms consist of aching that occurs during work but resolves completely with rest. If left unaddressed, the symptoms progress to an intermediate stage, where they persist even after cessation of work. The final phase consists of chronic symptoms, where discomfort never resolves, even with elimination of the triggering factor. In our survey, we found that among surgeons who had musculoskeletal symptoms, 13.6 percent were in the chronic phase. This is alarming, because these symptoms may become irreversible at that point.

The corollary is that developing good habits early is essential for a long and productive career in plastic surgery. Many survey respondents compared plastic surgery to an endurance sport, and stated that they wished they had taken better care of their bodies early in their careers. In addition to leaning the steps of an operation, trainees have an invaluable opportunity to learn healthy ergonomic habits from their mentors in the operating room. Although there is no evidence that paying attention to ergonomics earlier in one's career reduces the risk of musculoskeletal injuries, there is clear evidence that core-strengthening exercises and stretching exercises mitigate those injuries. Patient care is enhanced when surgeons are healthier,[1,2] and it is in the best interest of our patients that we pay attention to our own bodies. It is also recommended that plastic surgeons should consider specialty-specific disability insurance to protect themselves in case such symptoms develop.

Our survey includes a large number of respondents from three different regions, encompassing the entire spectrum of plastic surgery. Our response rate of 26.1 percent is a statistically valid response rate, and is actually one of the highest response rates of any previously published or presented American Society of Plastic Surgeons survey, which have response rates between 9.9 and 20.1 percent.[44–49] That being, said, there are intrinsic limitations of any survey-based study, including the lack of objective data. In addition, our survey is not validated, as musculoskeletal issues among plastic surgeons have not been previously studied and therefore there was no preexisting validated questionnaire available. The purpose of the questionnaire, however, was simply to measure prevalence of certain issues. A further limitation is that

we do not have data on nonresponders in our study. Even though the surveyed American Society of Plastic Surgeons population was statistically representative of the entire Society, responders may not be representative of the population of plastic surgeons at large. That being said, it is not apparent that there exists bias toward surgeons with musculoskeletal symptoms being more likely to respond to our survey, as the rate of musculoskeletal symptoms in responders is within the range of previously published rates (94 percent among plastic surgeons,[8] 90 to 94 percent among Mohs surgeons,[5,6] 78.2 percent among pediatric laparoscopic surgeons,[4] and 62 percent among pediatric otolaryngologists[3]). On analysis, though, the recommendations presented stem from the advice of hundreds of plastic surgeons at various stages of their careers. Although this is the first large study on musculoskeletal injuries in plastic surgeons, the recommendations that we were able to extract from our participants' responses are in full agreement with the published ergonomics literature.

CONCLUSIONS

Musculoskeletal injuries are very common among plastic surgeons, regardless of subspecialty. To sustain a long productive career, plastic surgeons must pay attention to established ergonomic principles in the operating room, and condition their body outside the operating room. We found that musculoskeletal injuries were more common in U.S. surgeons than in Norwegian surgeons. Our survey delineates the prevalence and nature of musculoskeletal injuries in plastic surgeons, and helps develop specific recommendations to reduce the incidence and severity of those injuries. It would be interesting to see the results of future surveys including surgeons from other cultures, such as Asia and Eastern Europe.

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REFERENCES

1. Bentz ML. The plastics surgeon at work and play: Surgeon health, practice stress, and work-home balance. *Plast Reconstr Surg Glob Open* 2016;4:e1081.
2. Shanafelt TD, Gorringe G, Menaker R, et al. Impact of organizational leadership on physician burnout and satisfaction. *Mayo Clin Proc.* 2015;90:432–440.
3. Cavanagh J, Brake M, Kearns D, Hong P. Work environment discomfort and injury: An ergonomic survey study of the American Society of Pediatric Otolaryngology members. *Am J Otolaryngol.* 2012;33:441–446.
4. Esposito C, El Ghoneimi A, Yamataka A, et al. Work-related upper limb musculoskeletal disorders in paediatric laparoscopic surgery: A multicenter survey. *J Pediatr Surg.* 2013;48:1750–1756.
5. Liang CA, Levine VJ, Dusza SW, Hale EK, Nehal KS. Musculoskeletal disorders and ergonomics in dermatologic surgery: A survey of Mohs surgeons in 2010. *Dermatol Surg.* 2012;38:240–248.
6. Esser AC, Koshy JG, Randle HW. Ergonomics in office-based surgery: A survey-guided observational study. *Dermatol Surg.* 2007;33:1304–1313; discussion 1313–1314.
7. Gofrit ON, Mikahail AA, Zorn KC, Zagaja GP, Steinberg GD, Shalhav AL. Surgeons' perceptions and injuries during and after urologic laparoscopic surgery. *Urology* 2008;71:404–407.
8. Soueid A, Oudit D, Thiagarajah S, Laitung G. The pain of surgery: Pain experienced by surgeons while operating. *Int J Surg.* 2010;8:118–120.
9. Gjerberg E. Women doctors in Norway: The challenging balance between career and family life. *Soc Sci Med.* 2003;57:1327–1341.
10. Tucker P, Bejerot E, Kecklund G, Aaronson G, Åkerstedt T. *Doctors' Work Hours in Sweden: Their Impact on Sleep, Health, Work-Family Balance, Patient Care and Thoughts about Work.* Stockholm, Sweden: Stockholm Stress Center; 2013.
11. Green BN. A literature review of neck pain associated with computer use: Public health implications. *J Can Chiropr Assoc.* 2008;52:161–167.
12. Halpern M. Prevention of low back pain: Basic ergonomics in the workplace and the clinic. *Baillieres Clin Rheumatol.* 1992;6:705–730.
13. Bovenzi M, Zadini A, Franzinelli A, Borgogni F. Occupational musculoskeletal disorders in the neck and upper limbs of forestry workers exposed to hand-arm vibration. *Ergonomics* 1991;34:547–562.
14. Hoe VC, Urquhart DM, Kelsall HL, Sim MR. Ergonomic design and training for preventing work-related musculoskeletal disorders of the upper limb and neck in adults. *Cochrane Database Syst Rev.* 2012;8:CD008570.
15. International Ergonomics Association. Definitions and domains of ergonomics. Available at: http://www.iea.cc/whats/. Accessed October 10, 2017.
16. Nguyen NT, Ho HS, Smith WD, et al. An ergonomic evaluation of surgeons' axial skeletal and upper extremity movements during laparoscopic and open surgery. *Am J Surg.* 2001;182:720–724.
17. Rosenblatt PL, McKinney J, Adams SR. Ergonomics in the operating room: Protecting the surgeon. *J Minim Invasive Gynecol.* 2013;20:744.
18. Indramohan VP, Ashford R, Khan S, Lintern M. Are surgeon's content with the current surgical headgear systems? *J Med Eng Technol.* 2012;36:366–371.
19. Hayes MJ, Osmotherly PG, Taylor JA, Smith DR, Ho A. The effect of loupes on neck pain and disability among dental hygienists. *Work* 2016;53:755–762.
20. Lindegård A, Gustafsson M, Hansson GÅ. Effects of prismatic glasses including optometric correction on head and neck kinematics, perceived exertion and comfort during dental work in the oral cavity: A randomised controlled intervention. *Appl Ergon.* 2012;43:246–253.
21. Lenoir C, Steinbrecher H. Ergonomics, surgeon comfort, and theater checklists in pediatric laparoscopy. *J Laparoendosc Adv Surg Tech A* 2010;20:281–291.
22. Morse T, Bruneau H, Cherniak M, et al. Musculoskeletal disorders of the neck and shoulders in dental hygienists and dental hygiene students. *J Dent Hyg.* 2007;81:1–16.

23. Miller K, Benden M, Pickens A, Shipp E, Zheng Q. Ergonomics principles associated with laparoscopic surgeon injury/illness. *Hum Factors* 2012;54:1087–1092.
24. Szeto GP, Straker LM, O'Sullivan PB. A comparison of symptomatic and asymptomatic office workers performing monotonous keyboard work: 1. Neck and shoulder muscle recruitment patterns. *Man Ther.* 2005;10:270–280.
25. Cagnie B, Danneels L, Van Tiggelen D, De Loose V, Cambier D. Individual and work related risk factors for neck pain among office workers: A cross sectional study. *Eur Spine J.* 2007;16:679–686.
26. Szeto GP, Straker LM, O'Sullivan PB. A comparison of symptomatic and asymptomatic office workers performing monotonous keyboard work: 2. Neck and shoulder kinematics. *Man Ther.* 2005;10:281–291.
27. Stock SR. Workplace ergonomic factors and the development of musculoskeletal disorders of the neck and upper limbs: A meta-analysis. *Am J Ind Med.* 1991;19:87–107.
28. Chaffin DB. Localized muscle fatigue: Definition and measurement. *J Occup Med.* 1973;15:346–354.
29. Hagberg M. Local shoulder muscular strain: Symptoms and disorders. *J Hum Ergol (Tokyo)* 1982;11:99–108.
30. Feldman RG, Goldman R, Keyserling WM. Classical syndromes in occupational medicine: Peripheral nerve entrapment syndromes and ergonomic factors. *Am J Ind Med.* 1983;4:661–681.
31. Menzel NN. Psychosocial factors in musculoskeletal disorders. *Crit Care Nurs Clin North Am.* 2007;19:145–153.
32. Pillastrini P, de Lima E, Sá Resende F, Banchelli F, et al. Effectiveness of global postural re-education in patients with chronic nonspecific neck pain: Randomized controlled trial. *Phys Ther.* 2016;96:1408–1416.
33. Ylinen J, Takala EP, Nykänen M, et al. Active neck muscle training in the treatment of chronic neck pain in women: A randomized controlled trial. *JAMA* 2003;289:2509–2516.
34. Donchin M, Woolf O, Kaplan L, Floman Y. Secondary prevention of low-back pain: A clinical trial. *Spine (Phila Pa 1976)* 1990;15:1317–1320.
35. Kellett KM, Kellett DA, Nordholm LA. Effects of an exercise program on sick leave due to back pain. *Phys Ther.* 1991;71:283–291; discussion 291–293.
36. Takala EP, Viikari-Juntura E, Tynkkynen EM. Does group gymnastics at the workplace help in neck pain? A controlled study. *Scand J Rehabil Med.* 1994;26:17–20.
37. Linton SJ, van Tulder MW. Preventive interventions for back and neck pain problems: What is the evidence? *Spine (Phila Pa 1976)* 2001;26:778–787.
38. Berguer R, Hreljac A. The relationship between hand size and difficulty using surgical instruments: A survey of 726 laparoscopic surgeons. *Surg Endosc.* 2004;18:508–512.
39. Eklund G, Hagbarth KE. Normal variability of tonic vibration reflexes in man. *Exp Neurol.* 1966;16:80–92.
40. Lozano-Calderón S, Anthony S, Ring D. The quality and strength of evidence for etiology: Example of carpal tunnel syndrome. *J Hand Surg Am.* 2008;33:525–538.
41. Cheesborough JE, Gray SS, Bajaj AK. Striking a better integration of work and life: Challenges and solutions. *Plast Reconstr Surg.* 2017;139:495–500.
42. Miyake S. Clinical features of occupational cervicobrachial disorder (OCD). *J Hum Ergol (Tokyo)* 1982;11:109–117.
43. Browne CD, Nolan BM, Faithfull DK. Occupational repetition strain injuries: Guidelines for diagnosis and management. *Med J Aust.* 1984;140:329–332.
44. Sinno S, Mehta K, Simmons C, Stuzin JM. Current trends in facial rejuvenation: An assessment of ASPS members utilization of fat grafting during facelifting. *Plast Reconstr Surg.* 2015;136:20e–30e.
45. Choudry U, Kim N. Preoperative assessment preferences and reported reoperation rates for size change in primary breast augmentation: A survey of ASPS members. *Plast Reconstr Surg.* 2012;130:1352–1359.
46. Vargas CR, Chuang DJ, Lee BT. Assessment of patient health literacy: A national survey of plastic surgeons. *Plast Reconstr Surg.* 2014;134:1405–1414.
47. Paik AM, Daniali LN, Lee ES, Hsia HC. Local anesthetic use in tumescent liposuction: An American Society of Plastic Surgeons survey. *Ann Plast Surg.* 2015;74:145–151.
48. McIntyre JK, Gosman AA. Safety and quality on international surgical trips: Results from a comprehensive survey of American Society of Plastic Surgery (ASPS) members. Paper presented at: Plastic Surgery The Meeting 2015, American Society of Plastic Surgeons Annual Meeting; October 16–20, 2015; Boston, Mass.
49. McIntyre JK, Jubbal KT, Gosman AA. The economics of volunteering abroad: Results from a comprehensive survey of American Society of Plastic Surgery (ASPS) members. Paper presented at: Plastic Surgery The Meeting 2015, American Society of Plastic Surgeons Annual Meeting; October 16–20, 2015; Boston, Mass.