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Musculoskeletal disorders among robotic surgeons: A questionnaire analysis

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Summary ***Objective: Robotic surgical systems offer better workplace in order to relieve surgeons from prolonged physical efforts and improve their surgical outcomes. However, robotic surgery could produce musculoskeletal disorders due to the prolonged sitting position of the operator, the fixed position of the console viewer and the movements of the limbs. Until today, no one study has been reported concerning the association between robotics and musculoskeletal pain. The aim of this work was verify the prevalence of musculoskeletal disorders among Italian robotic surgeons.***
Material and methods: Between July 2011 and April 2012 a modified Standardized Nordic Questionnaire was delivered to thirty-nine Italian robotic centres. Twenty-two surgeons (56%) returned the questionnaires but only seventeen questionnaires (43.5%) were evaluable.
Results: Seven surgeons (41.2%) reported musculoskeletal disorders, by since their first use of the robot which significantly persisted during the daily surgical activity (P < 0.001). Regarding the body parts affected, musculoskeletal disorders were mainly reported in the cervical spine (29.4%) and in the upper limbs (23.5%). Six surgeons (35.3%) defined the robotic console as less comfortable or neither comfortable/uncomfortable with a negative influence on their surgical procedures.
Conclusions: In spite of some important limitations, our data showed musculoskeletal disorders due to posture discomfort with negative impact on daily surgical activity among robotic surgeons. These aspects could be due to the lack of ergonomic seat and to the fixed position of the console viewer which could have produced an inadequate spinal posture. The evaluation of these postural factors, in particular the development of an integrated and more ergonomic chair, could further improve the comfort feeling of the surgeon at the console and probably his surgical outcomes.

KEY WORDS: Robotics; Musculoskeletal diseases; Pain; Neck pain; Posture; Ergonomics.

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INTRODUCTION

The implementation of advanced robotic instruments today offers operators minimally invasive options for a wide range of complex surgical procedures (1-2). In fact, the use of the robot allows the surgeon to operate on small areas with an improved technical accuracy reducing the size of the surgical wound and providing many advantages in the postoperative recovery of the patient (3). As with all the newer working technologies, robotic surgical systems also offer better workplaces in order to relieve surgeons from prolonged physical efforts and improve their surgical outcomes (4). In fact, when using the robot, the surgeon operates seated at the console with the arms and elbows placed on a soft plane in order to allow free movement of the wrists and fingers which grasp two master controls located below the display. However, in spite of this more comfortable workplace, compared to traditional surgical approaches, robotic surgery can also produce many musculoskeletal disorders due to the prolonged sitting position of the operator who needs to maintain the image of the operative area through a semi-vertically oriented binocular viewer and adequately coordinate arm, wrist and lower limb movements (5-9). To date, no previous study has investigated the association between robotic surgery and musculoskeletal pain, probably due to the recent introduction of this technology. The aim of this work is to verify, using a specific questionnaire, the development of recurrent musculoskeletal disorders in a sample of Italian robotic surgeons.

MATERIALS AND METHODS

In the period between July 2011 and April 2012, a simplified version of the validated Standardized Nordic Questionnaire was prepared and delivered to thirty-nine Italian robotic centers (10-11). The questionnaire focused on the pain reported by the surgeon from the beginning of his robotic experience and during his daily robotic activity. In particular, the items took into consideration the amount of robotic experience achieved by each surgeon, the weekly use of the robot, the development of any recurrent musculoskeletal pain during the

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Table 1.

Surgeons' characteristics. The data regarding the age, duration of robot use and number of procedures are reported as mean with range between parentheses. The data concerning the gender, geographical area and type of robotic surgery are reported as percentages.

Number (n)		17
Age (years)		51.3 (32-61)
Gender	Male Female	16/17 (94%) 1/17 (6%)
Italian geographical area (n -%-)	North-west North-east Middle	5/17 (29.6%) 6/17 (35.2%) 6/17 (35.2%)
Duration of robot use/Surgeon's robotic experience (months)		36 (12-63)
Weekly use of the robot (hours)		6 (5-7)
Weekly number of robotic procedures (n)		2.2 (2-3)
Robotic surgery (n -%-)	Urology General surgery Gynaecology	12/17 (70.5%) 4/17 (23.5%) 1/17 (6%)
Concomitant standard laparoscopy (n -%-)		3/17 (17.6%)

robotic procedures and the possible influence of this pain on daily surgical activity. Lastly, a self reported ergonomic evaluation of the comfort feeling during robotic surgery was also included. Twenty-two surgeons (56%) returned the questionnaires. Five questionnaires were excluded due to incomplete or inaccurate compilation. In total, seventeen questionnaires (43.5%) received from different Italian robotic centers were deemed evaluable (Table 1). In December 2011, all questionnaire data were analyzed anonymously and statistically evaluated.

Statistical analysis

The data was analyzed using the Median and 25th-75th percentile for numerical variables and counts, and percentages for categorical variables were also reported. The Fisher test was used in order to evaluate the association between the development of pain from the first use of the robot and its persistence during subsequent daily surgical activities and the association between the comfort posture and the development of musculoskeletal disorders.

A non-parametric Mann-Whitney test was performed to evaluate any differences between groups with and without musculoskeletal pain regarding the number of months and hours per week spent at the robotic console. A p-value of 0.05 was considered statistically significant. The analyses were performed using SPSS (version 18.0; IBM Corporation).

Results

The questionnaire data reported by the seventeen robotic surgeons are shown in Table 2.

All of the surgeons were expert robotic operators and none of them reported any musculoskeletal pain before starting robotic surgery.

Seven operators (41.2%) declared having recurrent musculoskeletal pain which started with the first use of the robot, while six surgeons (35.3%) reported feeling pain during their daily surgical activities. As regards the association between these data, among the surgeons who reported the onset of pain from the first robotic procedure, a significant amount (85.7%) declared its persistence during the following daily surgical activities ($P < 0.001$).

Concerning the association between musculoskeletal pain and the duration of robot use, although both the median values related to the time spent from the first robotic procedure and the weekly use of the robot resulted higher among those surgeons who declared musculoskeletal pain, no statistically significant difference was assessed between these data (Figures 1 and 2).

As regards the body parts affected by musculoskeletal disorders, they were mainly reported in the cervical spine (29.4%) and in the upper limbs (23.5%).

Concerning the self-reported ergonomic evaluation of the comfort feeling during robotic surgery, six surgeons (35.3%) defined the robotic console as less comfortable or neither comfortable/uncomfortable with a negative influence on the surgical procedures. With regard to the association between comfort posture evaluation and the development of musculoskeletal disorders, despite 8 out of 10 surgeons who didn't report any musculoskeletal disorder defining the robot console as comfortable while 4 out of 7 surgeons affected by musculoskeletal pain

Table 1.

Answers to the questionnaire items reported by the robotic surgeons. The data shows the number of patients with percentages in parentheses.

Questionnaire	N° of patients (%)
Musculoskeletal pain before the first robotic operation	
No	17/17 (100%)
Yes	0/17 (0%)
Recurrent musculoskeletal pain since the first robotic operation	
No	10/17 (58.8%)
Yes	7/17 (41.2%)
Recurrent musculoskeletal pain during daily surgical activity	
No	9/17 (52.9%)
Yes	6/17 (35.3%)
Non-responders	2/17 (11.8%)
Body parts affected by pain*	
Cervical spine	5/17 (29.4%)
Thoracic spine	2/17 (11.8%)
Upper Limbs	4/17 (23.5%)
Lower Limbs	1/17 (5.9%)
Lombar spine	1/17 (5.9%)
None	10/17 (58.8%)
Console posture evaluation	
Less comfortable	2/17 (11.8%)
Neither comfortable nor uncomfortable	4/17 (23.5%)
Comfortable	11/17 (64.7%)
Interference with surgical procedures	
No	6/17 (35.3%)
Yes	6/17 (35.3%)
Non-responders	5/17 (29.4%)

**: Each operator could mark more than one answer.*

Figure 1.

The figure shows the association between musculoskeletal pain and the time spent from the first robotic procedure.

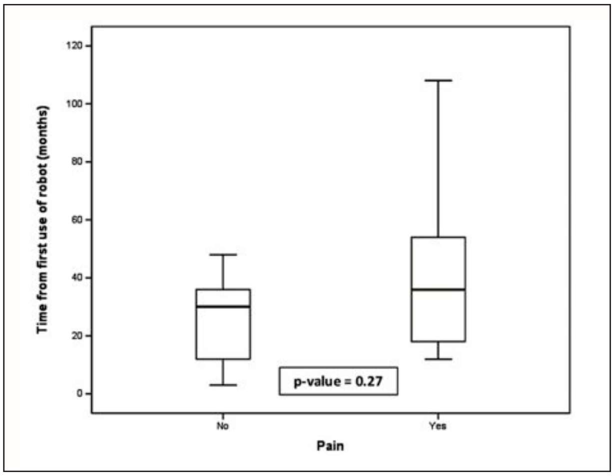
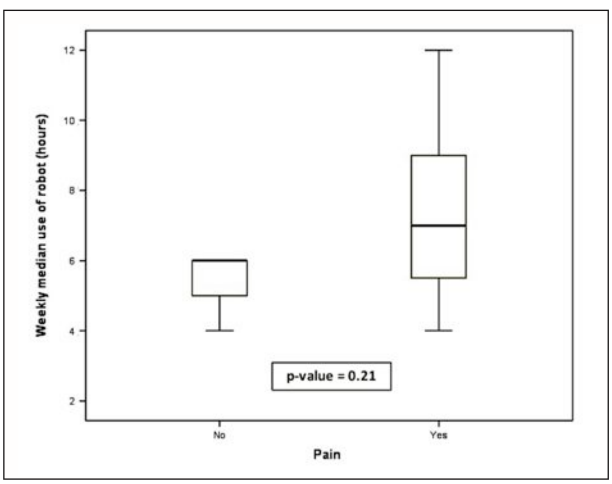


Figure 2.

The figure shows the association between musculoskeletal pain and the weekly use of the robot.



defined the robotic console as less comfortable or neither comfortable/uncomfortable, no statistical association ($p = 0.16$) was assessed between these two data.

Discussion

Work related musculoskeletal disorders represent a frequent problem among the general population with a prevalence ranging from 13.5 and 47% (12-14). Many studies have also investigated this aspect among the health workforce showing musculoskeletal pain between 17-66%, 81.5-82.9% and 28-70% in dental operators, open and laparoscopic surgeons, respectively (15-18). Robotic surgical systems offer better workplaces which should relieve surgeons from prolonged physical efforts and decrease the incidence of musculoskeletal pain. However, until today, no one study has been available in literature concerning the association between robotic surgery and musculoskeletal pain. The aim of this study was to verify the development of recurrent musculoskeletal disorders among surgeons who usually work with this new and high-tech surgical system. We also focused our attention on the robotic surgeons' feeling of comfort during the operations and the possible interference of any discomfort on their daily surgical activity. In our study, 41.2% of surgeons reported a recurrent musculoskeletal disorder, mainly neck pain, which started from the beginning of the robotic experience and substantially continued to impact negatively on the daily surgical activity ($p < 0.001$). Furthermore, 35.3% of surgeons defined the robotic console as rather uncomfortable with a negative influence on the surgical procedures. These data seem to point out the presence of some ergonomic problems at the robotic workstation. Actually, the correlation between the sitting working position and the presence of musculoskeletal discomfort or neck pain has already been reported in literature by many authors, especially among those workers who need to maintain an even gaze, only 20° below the horizontal line, for at least one hour, like robotic surgeons (19-21). In fact, as recommended by the United States Department of Labor's Occupational Safety and Health Administration (OSHA), a correct working sitting position requires many conditions including an appropriate positioning of the upper and lower limbs and a relaxed spinal posture with less inclination of the cervical region and adequate lumbar support (22). In spite of the fact that robotic workplaces allow good positioning of the upper arms with alignment of the forearms and hands, moderate relaxation of the arms and shoulders and bending of the elbows between 90 and 120 degrees, they don't provide similar attention to the positioning of the spine or the lower limbs. In fact, because a chair is not usually sold together with the robotic console, surgeons often resort to using a simple stool which doesn't provide any support to the hips or the lumbar spine (Figure 3). Furthermore, although all the Da Vinci surgical systems provide the opportunity to adapt the height of the console binocular viewer, only the newest model also allows the surgeon to modify its inclination, the height of the forearm supports and the position of the pedals (23). In our study, none of the robotic surgeons reported using this latest version of the Da Vinci system and this aspect could contribute to explaining the posture discomforts derived from the questionnaire data. Further studies will certainly verify the impact of the newest surgical robotic system on surgeons' postural pain. However, a more correct design of the sitting workstation remains a crucial point in order to respect the posture of the spine and to reduce neck and shoulder pain among people working with a protracted or retracted head position (20, 24-26). As regards the Da Vinci robotic system, an integrated and more ergonomic seat could further improve the comfort of the surgeon, thus minimizing the risk of musculoskeletal pain.

This study has some important limitations: it is a retrospective, not comparative, study and it is based on a low number of questionnaires. These aspects could decrease the reliability of our statistical evaluation especially since surgeons who reported musculoskeletal pain after robotic surgery may have been more likely to join the study than those who experienced no pain. This is mainly due to the presence of few robotic centers in Italy and, in particular, few surgeons who use the Da Vinci Robot regularly. In this setting, the aim of this study was to present our preliminary data which strongly needs to be confirmed by a larger study among all European robotic surgeons.

Conclusion

In spite of the new workplaces, our data showed recurrent musculoskeletal disorders and posture discomfort with a negative impact on daily activity in 41.2% and 35.3% of robotic surgeons, respectively. These aspects could be due to the lack of an ergonomic seat and to the fixed position of the console binocular viewer which could have produced an inadequate spinal posture with consequent musculoskeletal disorders. The evaluation of these postural aspects, in particular the development of an integrated and more ergonomic chair, could further improve the comfort feeling of the surgeon at the console and probably his surgical outcomes.

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References

1. *Jayaraman S, Quan D, Al-Ghamdi I, et al. Does robotic assistance improve efficiency in performing complex minimally invasive surgical procedures? Surg Endosc. 2010; 24:584-588.*

2. *Stefanidis D, Wang F, Korndorffer JR Jr, et al Robotic assistance improves intracorporeal suturing performance and safety in the operating room while decreasing operator workload. Surg Endosc. 2010; 24:377-382.*

3. *Lang BH, Chow MP. A comparison of surgical outcomes between endoscopic and robotically assisted thyroidectomy: the authors' initial experience. Surg Endosc. 2011; 25:1617-1623.*

4. *Lee J, Chung WY. Current status of robotic thyroidectomy and neck dissection using a gasless transaxillary approach. Curr Opin Oncol. 2012; 24:7-15.*

5. *Bagrodia A, Raman JD. Ergonomics considerations of radical prostatectomy: physician perspective of open, laparoscopic, and robot-assisted techniques. J Endourol. 2009; 23:627-633.*

6. *Aaras A, Horgen G, Bjorset HH, et al. Musculoskeletal, visual and psychosocial stress in VDU operators before and after multidisciplinary ergonomic interventions. A 6 years prospective study--Part II. Appl Ergon. 2001; 32:559-571.*

7. *Côté P, van der Velde G, Cassidy JD, et al. The burden and determinants of neck pain in workers: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. J Manipulative Physiol Ther. 2009; 32:S70-86.*

8. *Lorusso A, Bruno S, Caputo F, L'Abbate N. Risk factors for musculoskeletal complaints among microscope workers. G Ital Med Lav Ergon. 2007; 29:932-937.*

9. *Szeto GP, Ho P, Ting AC, et al. Work related musculoskeletal symptoms in surgeons. J Occup Rehabil. 2009; 19:175-184.*

10. *Kuorinka I, Jonsson B, Kilbom A, et al. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Appl Ergon. 1987; 18:233-237.*

11. *Gobba F, Ghersi R, Martinelli S, et al. Italian translation and validation of the Nordic IRSST standardized questionnaire for the analysis of musculoskeletal symptoms. Med Lav. 2008; 99:424-443.*

12. *Cimmino MA, Ferrone C, Cutolo M. Epidemiology of chronic musculoskeletal pain. Best Pract Res Clin Rheumatol. 2011; 25:173-183.*

13. *Hogg-Johnson S, van der Velde G, Carroll LJ, et al. The burden and determinants of neck pain in the general population: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. J Manipulative Physiol Ther. 2009; 32:S46-60.*

14. *Madan I, Reading I, Palmer KT, Coggon D. Cultural differences in musculoskeletal symptoms and disability. Int J Epidemiol. 2008; 37:1181-1189.*

15. *Klussmann A, Gebhardt H, Liebers F, Rieger MA. Musculoskeletal symptoms of the upper extremities and the neck: a cross-sectional study on prevalence and symptom-predicting factors at visual display terminal (VDT) workstations. BMC Musculoskelet Disord. 2008; 9:96-98.*

16. *Harcombe H, McBride D, Derrett S, Gray A. Prevalence and impact of musculoskeletal disorders in New Zealand nurses, postal workers and office workers. Aust N Z J Public Health. 2009; 33:437-441.*

17. *Capone AC, Parikh PM, Gatti ME, et al. Occupational injury in plastic surgeons. Plast Reconstr Surg. 2010; 125:1555-1561.*

18. *Stomberg MW, Tronstad SE, Hedberg K, et al. Work-related musculoskeletal disorders when performing laparoscopic surgery. Surg Laparosc Endosc Percutan Tech. 2010; 20:49-53.*

19. *Caneiro JP, O'Sullivan P, Burnett A, et al. The influence of different sitting postures on head/neck posture and muscle activity. Man Ther. 2010; 15:54-60.*

20. *O'Sullivan PB, Dankaerts W, Burnett AF, et al. Effect of different upright sitting postures on spinal-pelvic curvature and trunk muscle activation in a pain-free population. Spine. 2006; 31:707-712.*

21. *Bonney RA, Corlett EN. Head posture and loading of the cervical spine. Applied Ergonomics. 2002; 33:415-417.*

22. *United States Departement of Labor. Occupational Safety & Health Administration. [homepage on the internet] Washington. Available from: http://www.osha.gov/SLTC/etools/computerworkstations/positions.html*

23. *Matthew, Lux MM, Marshall M, Erturk E, Joseph JV. Ergonomic evaluation and guidelines for use of the daVinci Robot system.J Endourol. 2010; 24:371-375.*

24. *Rempel DM, Wang PC, Janowitz I, et al. A randomized controlled trial evaluating the effects of new task chairs on shoulder and neck pain among sewing machine operators: the Los Angeles garment study. Spine. 2007; 32:931-938.*

25. *Stuart J. Horton Gillian M. Johnson, Margot A. Skinner. Changes in Head and Neck Posture Using an Office Chair With and Without Lumbar Roll Support. Spine. 2010; 35:E542-548*

26. *Falla D, O'Leary S, Fagan A, Jull G. Recruitment of the deep cervical flexor muscles during a postural-correction exercise performed in sitting. Manual Therapy. 2007; 12:139-143.*

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