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RESEARCH ARTICLE

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ERGONOMIC RISK ASSESSMENT IN SPINE SURGEONS DURING LIVE LAMINECTOMY PROCEDURE USING RAPID UPPER LIMB ASSESSMENT TOOL

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ABSTRACT

Background: While performing a Spine surgery, surgeon bends over the patient on the operative table and has to adapt uncomfortable postures and perform surgical manoeuvres for long duration of time. This unsuitable ergonomic environment results in multiple musculoskeletal complaints being experienced by the surgeon himself. **Objective and Methods:** As a part of integrated assessment, Rapid Upper Limb Assessment (RULA) was adopted to investigate ergonomic risks in Spine surgeons during Laminectomy surgeries by doing postural analysis using Direct Observation technique inside the Operation room, and scored them based on posture adopted, and correlated same with musculoskeletal discomfort experienced, that was assessed using Cornell Musculoskeletal Discomfort questionnaire (CMDQ). **Results:** Positive correlation was found between grand RULA scores and CMDQ scores. No correlation was found between grand RULA scores with age of surgeon, number of surgeries in a day, or week, and hours in operation room. The Grand RULA scores for 37/40 spine surgeons was 7 indicating high ergonomic risks in large majority of the evaluated group. **Conclusions:** Prevalence of such high ergonomic risks in the evaluated Spine Surgeons underlines the need for further evaluation, corrective measures, and postural training in these surgeons. **Application:** This paper stresses upon that ergonomically correct environment and postures should be adapted by surgeons during the surgical procedures to prevent musculoskeletal discomfort and disorders. This opens up a huge area of research and implementation to the medical device industry as well as medical and surgical training facilities to enable a common goal - Care of the Caregiver.

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INTRODUCTION

Ergonomics (or human factors) is the scientific discipline that is concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design, in order to optimise well-being and overall performance (Dull 2012). Ergonomic problems have been investigated in various medical professionals like physicians, laparoscopic surgeons, orthopaedic surgeons, general surgeons, dentists, cardiac sonographers, urologists and nurses (Anuar 2012; Bergeur 1999; Maryam 2008; Yassar 2011). Spine surgeons are group of medical professionals who often have to perform surgical procedures which often last for long

contiguous hours. Due to the position of the patient during open surgery (most commonly prone position), surgeons tend to lean forward towards or even over the surgical field to optimally visualise and manipulate the tissue. This awkward leaning forward position results in increased muscle activity to balance the upper body. A study in general surgeons revealed that following an open surgery, 30% of the surgeons reported pain and stiffness in the shoulders, neck and lower back (Albayrak 2007). Although, musculoskeletal injuries like neck strain, lumbar disc radiculopathy, cervical disc herniation, rotator cuff disease, varicose veins and lateral epicondylitis have all been reported in spine surgeons (Auerbach 2011), there is no data available on the postural analysis or ergonomic risks in this group while they are performing a surgery. RULA

(rapid upper limb assessment) is a survey method developed for use in ergonomic investigations of workplaces where work-related upper limb disorders are reported (McAtamney 1993) RULA has been used commonly in various health professions to study ergonomic risks as it is quick to administer and does not hinder the workplace activities. In this study we investigated the ergonomic risks in spine surgeons while performing a laminectomy, which is one of the most commonly performed surgeries, using Rapid Upper Limb Assessment tool.

Indraprastha Apollo Hospital, Nova Hospital - Kailash Colony and Nova Hospital - Kalkaji). Subjects, who were selected through purposive sampling, included spine surgeons, orthopaedic surgeons and neurosurgeons; the criteria for inclusion being that subjects should be surgeons regularly performing spine surgeries, inclusive of laminectomy surgery, currently practicing in various hospitals located in Delhi, and were willing to participate in the study. Surgeons unwilling to participate or not doing spine surgeries regularly were excluded from the study.

Table 1. Collective data for all the subjects

S. No.	Surgeon	Age	Gender	Years of Experience	Surgeries in a day	Surgeries in a week	Hours in OT in a day	Grand RULA Score	CMDQ Scores
1	GM	32	Male	5	3	10	10	7	12
2	NP	33	Male	7	3	8	6	7	3
3	BM	45	Male	11	2	4	8	7	15
4	VT	39	Male	14	3	10	12	7	18
5	KD	46	Male	16	3	10	12	7	0
6	MLB	45	Male	14	3	7	10	7	9.5
7	VS	41	Male	8	1	5	7	7	15
8	AN	43	Male	10	2	6	9	7	15
9	PB	31	Male	2	2	6	8	7	3
10	SS	52	Male	12	2	4	8	7	7
11	MK	32	Male	3.5	2	10	8	6	0
12	AJ	44	Female	14	1	3	8	5	3
13	HS	44	Male	9	2	5	8	7	10
14	RM	42	Male	14	1	5	8	7	10
15	AU	32	Male	5	1	5	8	7	0
16	KK	55	Male	12	1	5	8	6	6
17	SA	50	Male	15	2	6	6	7	10
18	AG	43	Male	8	1	5	6	7	10
19	RSC	42	Male	5	2	7	8	7	30
20	AG	35	Male	5	1	4	4	7	0
21	DS	44	Male	11	2	4	8	7	6
22	JG	30	Male	3	2	7	6	7	4.5
23	SS	45	Male	14	3	10	8	7	3
24	RA	39	Male	6	2	6	10	7	6
25	AKS	44	Male	9	2	5	8	7	9
26	RM	31	Male	3	3	10	8	7	4.5
27	RB	51	Male	9	2	4	6	7	3
28	AS	34	Male	6	1	2	2	7	7.5
29	RK	31	Male	3	2	4	4	7	7.5
30	VK	32	Male	3	2	3	4	7	9
31	AS	31	Male	3	2	5	5	7	3
32	KK	53	Male	15	1	4	5	7	9
33	RP	34	Male	5	1	5	3	7	9
34	MS	48	Male	12	1	4	3	7	7.5
35	HH	54	Male	24	2	6	3	7	10
36	AN	52	Male	21	2	5	3	7	15
37	MS	36	Male	4	2	6	8	7	7.5
38	ST	45	Male	9	2	5	5	7	6
39	SKS	52	Male	21	5	1	6	7	10
40	AK	35	Male	3	1	4	6	7	6
	Range	25		22	4	9	10	2	30
	Minimum	30		2	1	1	2	5	0
	Maximum	55		24	5	10	12	7	30
	Mean	41.18		9.34	1.95	5.63	6.825	6.9	7.99
	SD	7.759		5.581	0.846	2.284	2.4273	0.379	5.726

MATERIALS AND METHODS

In this Cross- Sectional Survey 40 subjects were evaluated from multiple hospitals in New Delhi (Indian Spinal Injuries Centre, Gobind Ballabh Pant Hospital, Sir Gangaram Hospital,

Consent form was obtained from the subject (chief surgeon), as well as from the patient being operated and the concerned OT manager for the evaluator (first author) to attend and observe the live surgery in progress and record the requisite observations for a detailed assessment. (Figure 1) RULA



(Rapid Upper Limb Assessment) was employed for recording of posture and ergonomic risks during laminectomy, providing a quick assessment of posture of the neck and trunk along with muscle function and the external loads experienced by the body (McAtamney 1993). Grand RULA scores were generated and Action level for each subject was processed. Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) was used to assess work related musculoskeletal discomfort. Scores were generated using the scoring guidelines (Hedge 1999). Nonparametric equivalents to the standard correlation coefficient, Spearman’s was used to find out the relationship between RULA scores and CMDQ scores. Also, relationship between RULA scores and age of the surgeon, hours in operation room, number of spine surgeries performed in a day, number of spine surgeries performed in a week was sought using Spearman’s correlation coefficient.

RESULTS

A sample of 40 spine surgeons were included, 39 males and 1 female. Mean age of the surgeons was 41.18 years, with a mean experience of 9.34 years; the mean number of spine surgeries in a day and week were 1.95 and 5.63 respectively. (Table 1) Out of 40 subjects, 92.5% had Grand RULA score of 7 (n = 37), 5% had Grand RULA score of 6 (n = 2) and only 2.5% (n = 1) had Grand RULA score of 5 (Table 2).

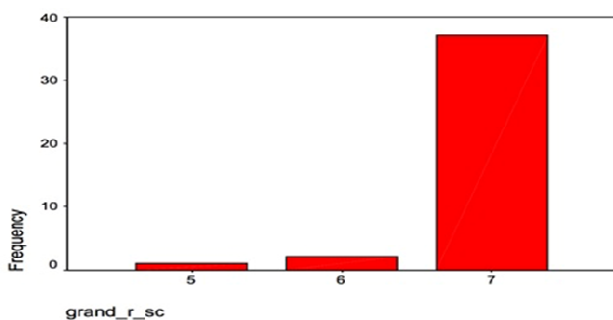
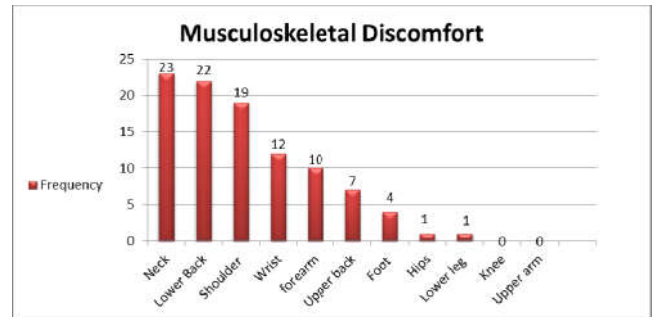


Table 2. Histogram of Grand RULA scores



Prevalence of discomfort in Neck (n=23), Lower back (n=22), Shoulder (n=19), Wrist (n=12), Forearm (n=10), Upper back (n=7), Foot (n=4), hips (n=1), and Lower Leg (n=1)

Table 3. CMDQ Scores

Analysis of CMDQ questionnaires (Table 3) that were completed by the subjects revealed that the most common painful sites were Neck (57.5%) followed by Lower back (55%) and Shoulder (47.5%) respectively. Spearman’s correlation coefficient was found out to be 0.302 and the p-value for this was 0.058. Thus there was a positive correlation between RULA scores and CMDQ scores, which was significant at 95% significance level for two tailed test. No correlation was found between grand RULA scores and age of the surgeons (p = 0.594), number of surgeries in a day (p = 0.142), or a week (p = 0.888), and hours in the operation room (p = 0.308).

DISCUSSION

This study aimed to evaluate the ergonomic risks in spine surgeons using Rapid Upper Limb Assessment (RULA) during Laminectomy. To our knowledge there is no study which assesses the posture and related ergonomic risks in spine surgeons during surgery in the operation room. Our data revealed that spine surgeons were at a huge disadvantage when it came to ergonomics they adopted in the operation room. 92.5% (n = 37) surgeons out of the study sample of 40, had Grand RULA score 7, and came in category Action level 4 which dictated that further evaluation and immediate corrective changes were required. We observed in this study that spine surgeons needed to acquire a posture which was characterised by frequent, awkward repetitive movement of the upper extremities with shoulder abduction past 90 degrees and internal rotation, with forearm rotating frequently with combinations of extension or flexion at the elbow with deviations at the wrist joint. The working hand holds the Kerrison rongeur tool to perform laminectomy. The neck was flexed and rotated at times which needed augmentation from the trunk rotation also. Trunk was flexed for majority of the procedure so as to have a closer look at the surgical field. (Figure 2). This posture seemed to be most awkward with upper limb joints positioned in extremes of their ranges and multiple repetitions required for a longer duration of time. In the above mentioned posture, there were multiple factors which made it highly unsafe and non-ergonomic. These factors included static and repetitive movements of the upper extremities and trunk and extreme joint positions during these postures at various moving joints which eventually lead to musculoskeletal complaints.



Roman-Liu et al suggested that it is a repetitive task of the upper limb that causes stress and musculoskeletal disorders which are very frequent in workplaces today and which should be reduced (Danuta 2005). Poor biomechanics (i.e., improper posture or motion) during repetitive tasks increases a person's risk of developing repetitive strain injuries (Voge 2003). Many studies suggest shoulder muscle overload as being the major cause for the increasing incidence of shoulder pain. One of the most common exposure factors was long durations with arms in abducted or flexed positions and a clear relationship between this and chronic rotator cuff tendonitis was demonstrated (Magnusson 1998). Poppen and Walker (1978) as well as Inman (1944) found the glenohumeral joint forces at 90 degrees of abduction to be close to the body weight. Repetitive movements; working in awkward positions including twisted postures, forward flexed trunk, and working with arms above shoulder level and prolonged periods of such postures were found to be associated with shoulder pain (Vander Windt 2000) Mirbod et al (1995) suggested that surgeons may be subjected to musculoskeletal complaints due to poor work postures, especially during operations, because of working with the arms abducted and unsupported and the cervical spine flexed forward and rotated as a high static load was imposed on the shoulder-neck region and shoulder joint.

Use of non-ergonomic devices and tools can put additional physical stress on the surgeons. A conventional Kerrison rongeur (Figure 3) is a manually operated instrument indicated for cutting or biting bone during surgery involving the spinal column and is used during laminectomy procedures. Conventionally designed Kerrison rongeur necessitates the continuous removal of resected bone chips which is a time-consuming activity. The architecture of the Kerrison Rongeur tool which was used by every subject in the present study contributed a lot to the stressful posture, adopted by a spine surgeon during the procedure. Lester and colleagues (2011) found that surgeons who used the Kerrison Rongeur were nearly 3 times more likely to develop carpal tunnel syndrome. Thus the design of the tools is an imperative step to be taken to make the operating room ergonomically safe. The use of high speed burrs by the surgeons to remove the bone might reduce the time of surgery and the ergonomic risks associated with



postures during the laminectomy procedures, but evaluation of such factors was beyond the scope of our study. We observed that surgeon's neck was in sustained flexion posture during the procedure. Geertje AM Ariëns et al (2000) reported that there was some evidence for a positive relationship between twisting or bending of the trunk at work and neck pain. There was also a positive relationship between neck pain and neck flexion, arm force, and arm posture i.e. between the times spent in upper arm abduction and self-reported neck symptoms, duration of (fixed) sedentary posture, twisting or bending of the trunk and workplace design factors. It has also been suggested that in forward flexed position of the head, the major load is carried by C7-T1 joint and compared to the normal upright position, there is 3.6 times greater load at this level (Magnusson 1998). We can also derive from our observations that, if the surgeon is using a foot stool, he/she has to further bend his trunk down which causes more stress on the shoulders, wrist and hand as they go into extremes of the range. Albayrak et al concluded that a head- and back-bent posture and twisted torso characterise the posture of the surgeon during open surgical procedures. Due to the position of patient during open surgery, surgeons tend to lean forward, to see the surgical field and manipulate the tissues, which results in increased muscle activity (Albayrak 2007). It has also been suggested that increased intra-discal pressures indicated a greater muscular effort in maintaining the posture for longer duration and hence a larger stress on spinal column (Sethi Jasobanta 2011). Trunk flexion increased the load and the forward-bending moment on the spine. The addition of twisting motion and accompanying torsional loads further increased the stresses on the disc (Nordin 2001). During a spine surgery, a surgeon has to deal with a non-optimal height of the operation table. Mostly the table height is adjustable, but the difference in the height of other team members might lead to poor ergonomics of the surgeon under evaluation and hence more physical stress on the upper extremities. It has been reported that the working surface height relative to a subject performing manual work determines upper extremity effort and the potential for musculoskeletal injury (Albayrak 2007). We also investigated the musculoskeletal discomfort experienced by spine surgeon by advocating Cornell Musculoskeletal Discomfort Questionnaire. Subjects complained of discomfort in various body parts and the predominant areas of musculoskeletal discomfort were Neck, lower back and shoulder and to some extent Wrist and forearm. Hips, Lower leg, Knees and Feet discomfort was found to be negligible. This could very well be explained on the basis of exposure of the surgeons' right since their initial days of surgical training which involves long hours of standing to assist in surgeries, thus making lower limbs usually more adjusted to the musculoskeletal effort and thus resulting in little discomfort. Our study used observation as the method of assessing the posture of a spine surgeon during a live

laminectomy procedure in the operation theatre. RULA was designed as observational tool to assess ergonomic risks on the musculoskeletal system. An advantage of doing a postural analysis by direct observation was that all the 3 planes of the movement could be evaluated at the same time. In our study, the investigator changed positions to view the posture of the subject from frontal (anterior and posterior) and sagittal planes. E. N. Corlett, the developer of RULA in a personal communication to the authors suggested that if any of other methods like photography or video-recording is used to assess the posture, only one plane of the movement can be assessed at a time. Also by using observation as the method of assessment, there was no hindering of the activities in the operation room (McAtamney 1993). In a study done on laparoscopic gastric bypass surgeons using RULA by video analysis, the authors reported their limitation that surgeon's posture was evaluated only from one side due to the set-up of the video camera, thus the results should be considered approximate, rather than absolute posture assessment (Lawson 2007).

Conclusions and Recommendations

We concluded that majority of spine surgeons were at ergonomic risks of developing musculoskeletal disorders, and required further evaluation and immediate changes to reduce these risks. It is suggested that proper surgical tools be employed while performance of such long duration procedures to reduce the time and effort, and to eliminate the need for adoption of ergonomically high risk postures. We also suggest that appropriate postural training be a part of the surgical training received by the spine surgeons during their formative years to lower the ergonomic risks later in their careers so as to reduce the risk of musculoskeletal problems.

Key Points

- Spine Surgeons are at an Ergonomic risk for developing musculoskeletal disorders while performing Spine Surgeries
- Rapid Upper Limb Assessment (RULA) was adopted in this study to investigate ergonomic risks in Spine surgeons during Laminectomy surgeries by doing postural analysis using Direct Observation technique (DOT) inside the Operation room.
- These ergonomic risks were correlated with musculoskeletal discomfort experienced, that was assessed using Cornell Musculoskeletal Discomfort questionnaire (CMDQ).
- High Ergonomic risks were identified in the majority of the study group, thus necessitating the need for further evaluation and suitable changes to be made to bring down the ergonomic risks for Spine Surgeons.

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