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Ergonomic Risk Assessment of Sonographers during Abdominal and Pelvic Sonography

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Abstract: ***Introduction: Identification of scan specific risk factors is crucial for controlling the increasing incidence ofwork-related musculoskeletal disorders in sonographers. Objectives: The purpose of this study was to conduct a physical ergonomic assessment of sonographers during abdominal and pelvic sonographies by RULA method and to study if any correlation exists between symptoms and RULA. Settings and Design: Cross sectional study design; Multicentric, tertiary health care centers. Methodology: 50 sonographers performing procedures for at least one year and consenting to participate were included in the study. Information of demographic and workload data along with past and present history of musculoskeletal symptoms which they attributed to work-related practices was obtained via questionnaires. RULA assessment was conducted while the sonologist was performing an abdominal/obstetric sonography scan, as it encompasses the major workload of sonologist. Statistical Analysis: Analysis of symptom prevalence and mean RULA scores was done and further statistical analysis was performed by Pearson's correlation statistics to check if any relationship exists between the RULA and symptoms. Result:58% sonographers reported neck pain, 32% low back and 13% upper back pain, 40% wrist and hand, 14% shoulder pain in the last week. The average total right RULA score and total left RULA score were 6.3 and 5.6 respectively. Statistical correlation represents mildpositivecorrelation (r=0.42, p<0.002*) between neck, trunk and leg RULA score and upper limb symptoms and weak (r=0.47,p<0.000*) relationship between right upper limb RULA scoreand spine symptoms. Conclusion: The one-week prevalence of work-related symptoms were 84% andone-year prevalencewas 58% in the sonographers participating in this study.The high RULA scores(>5)recorded in this study demand urgent attention and need to implement ergonomic changes in the working postures of sonographers.***

Keywords: sonographers, RULA, ergonomics, abdominal and pelvic procedures

1. Introduction

The prevalence of work related musculoskeletal symptoms in sonographers has been reported in large scale surveys to be as high as 80 %[1] to 90 %.[2]The common symptomatic areas reported in past surveys are neck and low back,[1,2,3,4,5] wrist-hand[1,2,4,5,6]shoulder[2,5]and elbow/forearm[2,4]. Commonest symptom sites reported by some authors are neck and low back,[1,3,4,7]whereas others have detected higher symptom prevalence in the upper extremity.[2,8]

With respect of the intensity of symptoms,Russo A et al have revealedthatalmost 50% respondents were suffering from severe symptoms.[9]Musculoskeletal disorders acquired by sonographers have also been reported as a precursor to long term disability, with the proportion of injuries increasing with the number of years spent practicing ultrasound.[10]The disconcerting fact is that a proportion of sonographers had even stopped working due to their symptoms.[1]

The two commonest contributory factors have been cited in previous literature as high hand grip pressure,[2,4,6,8]poor posture,[7,9,11,12,13]and ergonomically unsound habits.[8]Feng Q, Liu Set al, havediscussed various regional contributory risk factors to work related symptoms in sonographers.[11]However, these factors were reported by the sonographers, but were not formally assessed in these studies.

Although the reported prevalence is high, only a few studies[12,13,14]have quantified the risk factors in the work environment of a sonographer through formal assessment. Burnett and Campbell-Kyureghyan conducted onsite assessment to identify and quantify scan-specific risk-factors for upper extremity work-related musculoskeletal pain in sonography. They identified shoulder abduction and wrist deviation angles to be greater than previously published acceptable limits as risk factors for upper limb work related injuries.[13]Roll et al had conducted ergonomic analysis for 5 sonographic procedures viz. upper extremity venous, transvaginal, transabdominal, carotid duplex and upper extremity venous and quantified the RULA score for these procedures. They have indicated too that additional research is required to determine the relationship of positioning during other frequently performed sonographic evaluations (e.g. abdominal and echocardiogram).[12]

Burnett and Campbell-Kyureghyan have suggested that although all the investigated scans involve injury risk, the specific risk-factors and their relative importance varies between scan types.[13]Assessing scan-specific risk-factors, by on-site ergonomic job evaluations using quantitative biomechanical analysis have been pointed in earlier work(Roll, S. C et al) on sonographers and would be of paramount importance for effectual designing interventions to prevent/reduce injuries among sonographers.[12]

Hence the purpose of our study was to assess the postural ergonomic risk in sonologists with RULA scale while performing two most frequently performed scan types i.e. abdominal and obstetric. The other purpose was to test if any correlation exists between the discomforts reported and

postural constraints of sonographers from the standpoint of ergonomics.

2. Methodology

Institutional ethical committee approval was obtained prior to conducting the study. 50 sonographers performing procedures for at least one year and consenting to participate were included in the study. Sonographers with previous history of traumatic, or any systemic disease that would cause any pain and associated musculoskeletal problems or suffering from neurological illness were excluded from the study.

A pre-validated, structured questionnaire containing demographic and workload data along with past and present history of musculoskeletal symptoms which they attributed to work-related practices (modified version of the Standardised Nordic Questionnaire based on Kuorinka et al)[15]was administered to the participants.

The rapid upper limb assessment was used to quantitatively score the positioning of scanning and non-scanning arm and overall trunk posture of the participant.

The RULA is an observational tool that is commonly utilized to assess work postures and calculate physical risk of a work related task. Observed postural angles of the shoulder, elbow, forearm, and wrist are noted and tallied to provide sub-score for upper extremity.Similarly, a second sub-score is allocated to the neck, trunk and leg based on the postures. The repetitive or static muscle activity and the amount of load the anatomical area is subjected to is further incorporated into the 2 aforementioned scores. A final value from 1 to 7 is assigned to the overall activity position; a score of 1 is associated with a neutral or low risk posture and 7 denotes that changes in workplace are needed immediately due to hazardous postures. In the original version of this tool, MacAtamney and Corlett suggest that the overall scores indicate an action level; 1) 1 or 2= acceptable postures; 2) 3 or 4= further investigation, change may be needed; 3) 5 or 6= further investigation, change soon; 4) 7= investigate and implement the change.[16]

RULA assessment was conducted while the sonologist was performing an abdominal/obstetrics sonography scan which were chosen as they encompass the major workload of sonologist. Symptom prevalence and mean RULA scores were calculated for the study population. Further statistical analysis was performed to check if any correlation exists between the symptom scores and RULA scores.

Statistical analysis was performed using SPSS 16 version. Measures of average and dispersion were calculated. Spearman's test was done for correlation analysis.

3. Results

50 sonographers with an average(sd) age of 28 (+/-2.6) years and with work experience of 4.11(+/-2.45) consented to participate in the study. A structured questionnaire was used for obtaining the demographic and workload characteristics as well as musculoskeletal symptoms of the sonographers participating in this study (Table 1&4).All participants in the study were right handed by dominance. There was a higher number of male participants in our study (Table 1). The average time to perform single scans varied from 5 to 20 minutes (Table 2).

Table 1: Demographic and workload characteristics of the sonographers

Variable	*Value*
Age (years)	28+/- 2.6
Gender M:F ratio	29:21
Body Mass Index (BMI) category	2% - Underweight 68% - Normal 16% - Overweight 14% - Obese
Dominance Right: Left	50:0
Exercise participation	28%
Total working years	4.11(+/-2.45)
No of working days/week	5.64(+/-0.48)
No of hours/day	6.92(+/- 2.04)
Number of abdominalprocedures performed/month. Mean(sd)	300(+/-94)
Number of Obstetrics procedure performed/ month.Mean(sd)	280 (+/-80)
Musculoskeletal symptomprevalence (1 week)	84%
Musculoskeletal symptom prevalence (1 year)	58%

Table 2: Time required to perform single scan as reported by the sonographers

Time required to complete a single scan	% sonographers	% sonographers
20mins	8	10
15 mins	-	2
10min	52	50
5 min	40	38

Majority of the sonographers reported adopting erect posture while performing abdominal and pelvic scans. (Table 3)

Table 3: Posture adopted as reported by the sonographers while performing abdominal and obstetric scan

Posture adopted	While performing abdominal scan (% sonographers)	While performing obstetrics scan (% sonographers)
Erect and stoop sitting	38 %	36 %
Erect sitting	62 %	64 %

The following table (Table 4) indicates one-year and one-week prevalence of musculoskeletal symptoms in sonographers. The figures in the table below indicate both one-week and one-month prevalence of work related musculoskeletal symptoms was highest in the neck. The other areas reported by the participants of our study were low back, wrist, shoulder and wrist-hand.

Table 4: Presence of symptoms in last week and last year

	Shoulder	Wrist	Hand	Neck	Upper back	Lower back
In last week	14 (26%)	19 (38%)	1 (2%)	29 (58%)	13 (26%)	16 (32%)
In last year	10 (20%)	11 (22%)	3 (9%)	17 (34%)	9 (18%)	16 (32%)

The RULA scores of the sonographers while performing an abdominal or obstetric procedure are given in table below (Table 5). The RULA scores are presented in 5 subheadings viz.Neck trunk and leg;Left upper limb;Right upper limb; Total right and left RULA. The total right and left RULA scores are obtained after tallying the neck trunk leg with the respective upper limb scores. The results indicate that only a few sonographers scored in the acceptable range.

Table 5: RULA Scores and their interpretation of total score

RULA scores	1-2 (acceptable posture)	3-4 (further investigation, change may be needed)	5-6(further investigation, change soon)	>7 (investigate and implement change)
Neck, Trunk and leg	-	11	21	18
Left upper limb	5	38	6	1
Right upper limb	-	1	49	-
Total Left RULA	-	11	34	5
Total Right RULA		2	23	25

The correlation analysis of the symptoms and RULA are shown in table 6

Table 6: Correlation analysis of RULA scores and symptoms

Independent variable	Right and left limb symptoms (rate)		Spine symptoms (rate)		Presence of Right and left limb symptoms		Presence of Spine symptoms	
	r value	p-value	r value	P value	t- value	P value	T value	P value
Right upper limb RULA score	0.1	0.43	0.00	0.95	-0.5	0.06	-0.10	0.9
left upper limb RULA score	0.1	0.47	0.07	0.59	-1.4	0.04*	-0.77	0.4
Neck, trunk and leg RULA score	0.3	0.01	0.42	0.002*	-2.57	0.01*	-2.14	0.03*
Total Right upper limb RULA score	0.2	0.12	0.47	0*	-1.4	0.14	-2.49	0.01*
Total left upper limb RULA score	0.1	0.25	0.29	0.03*	-1.2	0.21	-2.01	0.04*

Correlation analysis indicates that there is a mild positive correlation between spinal symptoms and Neck, trunk and leg RULA (r=0.42) and total right upper limb RULA (r=0.47)

Spinal symptoms were influenced by neck, trunk and leg RULA (t (48) = -2.14, p =.03) and total right upper limb RULA (t (48) = -2.49, p =.01).

4. Discussion

Due to increase referrals and consequently the workload, there isa rise in prevalenceof workplace musculoskeletal symptoms in Diagnostic medical sonographers (DMS). Concerns regarding reported symptoms by diagnostic sonographers have and a necessity to control the same been raised to the National Institute of Occupational Safety and Health (NIOSH).[17]The objective of our study was to identify, through postural assessment, the relationship between the discomforts reported and postural constraints of sonographers from the standpoint of ergonomics.

This cross sectional multi-centric study, represents the result of ergonomic assessment performed on sonographers in government hospitals and private diagnostic centers situated in Mumbai and Navi Mumbai. 29 male sonographers and 21 female sonographers in age group of 20 to 40 years working for an average of 39 working hours /week consented to participate in this study. They reported performing at an average of 300(+/-94) abdominal and 280 (+/-80) obstetric procedures per month.

The result of the questionnaire on musculoskeletal symptoms revealed that theone-week prevalence of work-related symptoms in sonographers in our study was 84%. This is comparable to that reported in previous literature which indicate prevalence rates between 80 to 90%.[1,2,3,5,7,8,9,10,18]

There was a higher prevalence of spinal pain (80%)when compared to upper extremity pain (50%) in our study participants. This is similar to the findings of [1,3,5,7]in which they reported neck or low back pain[1,2,3,4,5] as the greatest symptom among sonologists and radiologists. However, our findings are dissimilar to the findings of authors who reportedthe commonest symptom site as upper extremity.[2,8]

Neck pain was reported as the highest prevalent symptom both at one-week (58%) and one-year(34%). One-week prevalence data indicate that the wrist pain (38%) was higher than low back pain (32%), whereas the one-year prevalence data reveal lower back pain (32%) was higher than the wristpain (22%). Shoulder and upper back were the next prevalent symptomatic areas occupying the fourth and fifth positions at one-week and one-year. [Table 4]

5. RULA Analysis

The results of the postural RULA analysis are depicted in table 5. Our results indicate that the average right upper limb RULA score (5.28) was higher than the left upper limb RULA score (3.58).A greater number of sonographers scored lower for the left than the right upper limb (Table 5). The average neck, trunk, leg RULA score was 6. The high neck, trunk scores led to high total right and left upper limb RULA scores of 6.3 and 5.4 respectively whichsuggest immediate attention and need for intervention in sonographers. The findings of our study confirm the presence of non-neutral neck, back, shoulder and wrist postures in sonographers while working in their environment as reported in earlier literature on risk factors.[12,13,14]

Our study RULA scores of transabdominal procedures were much higher (RULA score =6.3) than reported by Roll et al(RULA score =4.67). This difference could be due to the fact that the sonographers in their study were allowed to set-

up and adjust the work-space and arrangement as they wished and even adjustable patient bed was available.[12]Thenon-availability of the aforementioned factors could be the reason for higher RULA scores in our study. The authors (Roll et al) have also demonstrated that bed height had a significant influence on the neck and trunk RULA scores.[12]

Our postural analysis indicates that most sonographers flexed their neck in 10˚ to 20˚ angles and at other times adopted forward head posture. Along with this, the neck was rotated and bent to one side while scanning. Also the repetitive movements of the neck to view the screen and adjusting the transducer increased the neck score. At the trunk, although 62% to 64% sonographers reported having adopting erect sitting (Table 3),our trunk scores suggest that they constantly flexed their trunk in range of 0˚ to 20˚ with rotation and side-bending. The inappropriate position of the patient's plinth farther than required from sonographer forced them to slouch and rotate trunk repetitively to reach the patient.

Figure 1: Figure showing trunk slouching (flexion) adopted by sonologist

Majority of sonographers maintained the right shoulder between 20˚ to 45˚ of flexion and up to90˚ abduction. As the sonographers were positioned always on the right side of the patient,they often excessively abducted and elevated the right arm to reach on the opposite (left) sideof the patient's abdomen. Also for the most duration of the scan, the right arm was unsupported.

Figure 2: Figure showing arm abduction and wrist flexion posture adopted by sonologist

Elbow movements were in the ergonomic range of 60˚-100˚. During the procedure the wrist was positioned innon-neutral sagittal plane (up to 15˚of flexion or extension) and frontal plane (ulnar and radial deviation). Although the forearm was positioned for a larger part in mid-prone position,there were repeated movements of the wrist for adjusting the ultrasound probe on the abdominal wall. All these factors increased the average right total RULA scores to 6.3 in our study sonographers.

Although the left shoulder was in lower angle of elevation (flexion and abduction) the awkward wrist postures with the suboptimal ergonomic positioning of the keyboard increased the left RULA scores to 5.28

6. Recommendations

Awareness of simple ergonomic measures like reducing the abduction angles while scanning by positioning the table as near to the patient's plinth as possible, adjustable height plinth, adopting neutral and erect spinal postures while working, supported sitting, and supporting the scanning and non-scanning arm can be of great benefit. Murphey SL and Andy Milkowski have revealed the benefits of optimized scanning technique, workstation utilization and use of adjustable workstation equipment. They demonstrated that the left upper trapezius muscle activity decreased 65% by changing from a 50˚ forward shoulder flexion (reach) to a neutral (0° reach) position. The right suprascapular fossa activity showed a reduction of 46% between a postural stance of 75° abduction and 30° abduction. There was an even more dramatic reduction of 78% by providing support under the forearm at the same 30° abduction. These findings support the use of working with the arm in supported position with low elevation angles in sonographers. [19]

A stretch break or micro-breaks after every procedure would be of great benefit. A recentstudy by M.S. Hallbeckon surgeons demonstrated the effectiveness of micro-breaks to increase the work comfort[20]. Accordingly, such strategies could be utilized by sonographers. Also changing the scan types will change the muscle activation patterns could reduce the sustained posture and muscle activity adopted if they perform a single scan type repeatedly. This could be achieved by work planning and scheduling the appointments accordingly.

Correlation analysis (RULA and symptoms)

For further analysis, correlation was done to study the relation between the sonographer's symptoms and their RULA scores. Spearman's test was used to test correlation between symptom intensity (NPRS) and RULA.

The rate of symptoms of spine havemild correlation with neck, trunk and leg RULA score and total right upper limb RULA score with r=0.43 and r=0.47 respectively (Table 6). The relationship is positive: rate of spine symptoms increases as the Neck, trunk and leg RULA or Right total RULA score increases and vice-versa. This indicates that the spinal symptoms are influenced by the spinal and right upper limb awkward postures and they increase as the spinal or right total RULA scores increase.

The right and left upper extremities rate symptoms were weakly correlated with neck, trunk and leg RULA (r = 0.3. i.e.) as well as with extremity RULA scores (r=0.2 and r=0.1). Our results are dissimilar to Roll et al who had found a moderately positive association between (r=0.53, p<0.01) between upper extremity sub-score and discomfort(VAS).[12]However direct comparisons cannot be made between the 2 studies as they had computed the RULA during a variety of examinations (sonography procedures viz. upper extremity and lower extremity Doppler, carotid duplex, transvaginal pelvic and transabdominal obstetric) in a single set-up, whereas in our study a multi-centric scan-specific (abdominal and pelvic procedures) correlation between symptoms and RULA was performed.

These findings demonstrate that the spinal and right upper extremity positions influence the spinal symptom prevalence in sonographers. However, the presence ofmild correlationindicates that other factors like total number of procedures performed in a day, work duration, psychological factors, anthropometric differences between subjects, work experience, workstation height and arrangementetc. may also be contributory to the symptom prevalence. These factors were not included in analysis in our study as we aimed to assess the degree of association of symptoms to the postural flaws. Future studies can incorporate assessment of all risk factors in scan specific layout to assess the contribution and weightage of each component with regression analysis in influencing the work-related symptoms in sonographers.

Only 10% of our study sonographers were aware of the ergonomic recommendations which indicates a pressing need for improving awareness and immediate incorporation of feasible strategies to reduce the work-related symptoms in sonographers.

7. Conclusion

The overall one-week and one-year symptom prevalence of work-related musculoskeletal symptom was 84% and 58% respectively in the sonologists population.

The high left and right RULA scores (>5) indicate that immediate attention is needed to address the workplace with appropriate measures. Analysis indicates that the sonographers had the worst scores for the the neck and trunk.

There was a mild positive correlation of pain intensity at the neck and upper limb with neck and trunk RULA scores. Although it is a strong diagnostic tool for identification of physical ergonomic risk, the other factors such as workload, demographics, psychological, work stress etc. may also be important in contributing to the symptom severity and should be assessed and addressed in future research. Education, ergonomic interventions, workstation and equipment modifications are need of the hour to protect sonologists to meet increasing health care demands.

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