International Journal of Health Sciences and Research
Volume 14; Issue: 8; August 2024
Website: www.ijhsr.org
Original Research Article *ISSN: 2249-9571*

A Correlation Study to Analyze the Relationship Between Neck Pain, Level of Musculoskeletal Disorders (MSDs) Risk and Handgrip Strength in Desktop Workers

Kiruthika S[1], Prof. R. Mahesh[2], Indhu R[3]

[1,2,3]Department of Orthopedics, PSG Hospitals
PSG College of Physiotherapy, The Tamil Nadu Dr. M. G. R. Medical University, Coimbatore, India.

Corresponding Author: Kiruthika S

DOI: https://doi.org/10.52403/ijhsr.20240806

ABSTRACT

INTRODUCTION: Musculoskeletal Disorders (MSDs) are the most common disorder in Desktop workers. Among these MSDs, Neck pain causes the highest burden. Many ergonomic-related MSDs are primarily caused by ergonomic risk factors. Hand grip strength is the essential unit of Desktop workers. Neck disorders influence hand function which may be explained by the Double crush phenomenon. Neck pain, constrained postures and decreased handgrip strength may increase the injury risk, work of absence and loss of productivity.
OBJECTIVE: To analyze the relationship between Neck pain, Level of MSD risk and Handgrip strength in Desktop workers.
METHOD: In this Cross-sectional Correlational study design, 152 Desktop workers with Neck Pain were taken based on convenient sampling technique. Neck pain, Level of MSD risk and Handgrip strength were assessed by using VAS, RULA and Handheld Dynamometer for both the hands for 3 trials respectively. Data was collected and analyzed using Spearman's rho correlation coefficient.
RESULTS: Spearman's rho correlation between VAS and RULA was statistically significant, p= <.001 ($p<0.05$) indicating that the relationship was positive, moderate in strength, correlation between VAS and HGS was statistically significant, p value = <.001 ($p<0.05$) indicating that the relationship was negative, moderate in strength and the correlation between RULA and HGS was statistically significant, p value = <.001 ($p<0.05$) indicating that the relationship was negative, weak in strength.
CONCLUSION: Based on this statistical analysis, this study shows that there was a significant relationship between Neck Pain, Level of MSD risk and Handgrip strength in Desktop workers.

Keywords: Musculoskeletal disorder, Visual Analogue scale, Rapid Upper Limb Assessment, Handgrip strength, Handheld dynamometer.

INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) refer to musculoskeletal injuries induced or aggravated by work or the environment where the work is carried out [1]. Musculoskeletal disorders (MSDs) are

the most common disorder in Desktop workers due to their constrained postures, repetitive motion of upper extremity, vibration, and localized mechanical pressure. Among these MSDs, work related Neck pain is more common in Desktop workers because of improper posture and lower intensity stress and strain. Usually, desktop workers maintain prolonged static position of neck for more than 6 hours per day which increase stress on the neck and in turn cause Neck pain[15]. Four to five hours of daily computer use is also a noted risk factor for Neck pain[7].

Neck pain is defined as pain experienced from the base of the skull (occiput) to the upper part of the back and extending laterally to the outer and superior bounds of the shoulder blade [4]. The prevalence of Neck pain in computer users was 55 % of the people of age group 20 to 50 years [6]. The International Association for the Study of Pain (IASP) proposed the types of classification based on the duration of Neck pain as Acute (lasts less than 7 days), Sub acute (lasts more than 7 days but less than 3 months) and Chronic (3 months or more). [2] Among these types, non-specific chronic Neck pain affects two- thirds of Desktop workers [5]. Work-related Neck pain has a multidimensional etiology that is impacted by and associated with a wide range of Individual, Physical and Psychological factors. Individual factors include age, gender, body mass index, smoking, alcohol consumption, sleeping hours, leisure time, etc. Physical factors include years of experience in the desktop work, hours of daily work, frequency of breaks, physical tiredness at the end of the day, physical workload to the neck region, climatological conditions, etc. Psychosocial factors such as mental tiredness at the end of the day, job pressure, work variation and job satisfaction may also cause Neck Pain. Pathophysiological mechanisms of Neck pain disorders are as follows,

a) Selective and sustained activation of type I motor units due to sustained low-intensity tasks may lead to ca $^{2+}$ accumulation in the active motor units and other homeostatic disturbances due to limitation in local blood supply and metabolite removal in muscle compartment may develop muscle damage.
b) Nociceptor sensitization due to intra-muscular & shear forces.[13]

Desktop workers with Neck pain usually have a prolonged deep neck flexor muscle activity and reduced cervical extensors muscle activity associated with activation in the various bands of the trapezius producing mechanical stress and pain on cervicobrachial structures.

Many ergonomic-related MSDs are primarily caused by ergonomic risk factors like contact stress, incorrect posture, and repetition. Tasks like use of keyboard, Handling the mouse for longer time, using computer screen below the eye level, maintaining static postures for longer time and infrequent breaks may increase stress on the neck, back, and upper extremity and leads to Neck pain, Back pain, Headache and may also decrease Handgrip strength in Desktop workers.

RULA (rapid upper limb assessment) is a survey method developed for use in ergonomics investigations of workplaces where work-related upper limb disorders are reported. This tool requires no special equipment in providing a quick assessment of the postures of the neck, trunk and upper limbs along with muscle function and the external loads experienced by the body.[16]

Nearly 35 muscles are involved in the movement of the forearm and hand, with many of them involved in gripping activities.[18] The flexors of the forearm and hand contribute to grip strength, while the extensors of the forearm stabilize the wrist during gripping. Handgrip is the functional unit of Desktop workers. Handgrip strength is an anthropometric measurement that depicts the condition of the muscles in hand and forearm and it also provides an objective measure of the upper extremity's functional integrity. In desktop workers the

Handgrip strength may decrease due to the following reasons,

- Due to repetitive work in Desktop workers, microscopic tears in soft tissues and articular wear and tear develop over the years, which indirectly affect the Handgrip strength. [14].
- The imbalance in length tension relation of long flexors of forearm and overuse of intrinsic Hand muscles may lead to decrease in the force produced by them leading to decrease in the Hand grip strength. [15]

Hand grip strength is typically determined by a person's maximum voluntary force under normal biokinetic conditions by using Handheld Dynamometer. Hand held dynamometer testing is a useful diagnostic tool to determine loss of handgrip strength, which may indicate development of musculoskeletal disorders of the upper extremities. Owing to the low cost, simplicity, speed, and pain-free nature of the test to determine handgrip strength, regular testing and evaluation can provide indications of work conditions that have a direct impact on musculoskeletal disorders[17].

Muscles of Handgrip are supplied by cervical nerves. Neck disorders influence hand function which may be explained by the Double Crush Phenomenon (Simultaneous compression at 2 or more sites of the peripheral nerve) [10]. In Desktop workers, prolonged static position of neck can result in a cervical nerve root irritation causing neck pain (1st crush) and potential neurological symptoms along the peripheral nerve most commonly median nerve, which is caused by compression in the tight carpal canal (2nd crush). 40% of computer users have associated complaint like upper limb pain and paraesthesias which are related to neck posture.[3]

Neck pain, constrained postures and decreased handgrip strength are important factors in Desktop Workers, as these factors may increase the injury risk, work of absence and loss of productivity. Therefore, by analyzing the relationship between Neck pain, Level of MSD risk and Handgrip strength in Desktop workers, it may reduce the risk of injury, work absenteeism and in turn it increases the productivity. Till date, very few studies were focused making the correlation between Neck pain, Level of MSD risk and HGS. Therefore, this study was aimed to assess the relationship between Neck pain, Level of MSD risk and HGS in Desktop workers.

MATERIALS & METHODS

STUDY DESIGN: Cross-sectional Correlational study design

STUDY SETTING: The study was conducted in the Department of Orthopaedics, PSG hospitals, Coimbatore.

PARTICIPANTS: 152 desktop workers

SAMPLING: Convenience sampling method

INCLUSION CRITERIA: Age 20-40 years, Working for 6-8 hours a day, At least 1 year experience of being a computer operator, Chronic Neck pain (>3 months), Willing to participate, Able to do daily activities by themselves

EXCLUSION CRITERIA: History of Fracture, surgery of Neck and Upper Limb, Neck pain before joining the profession, Pain in other areas like shoulder, scapula, lumbar spine etc., Headache, Back pain, Increased secondary curvature, Neurological and other musculoskeletal disorders, Diabetic patients

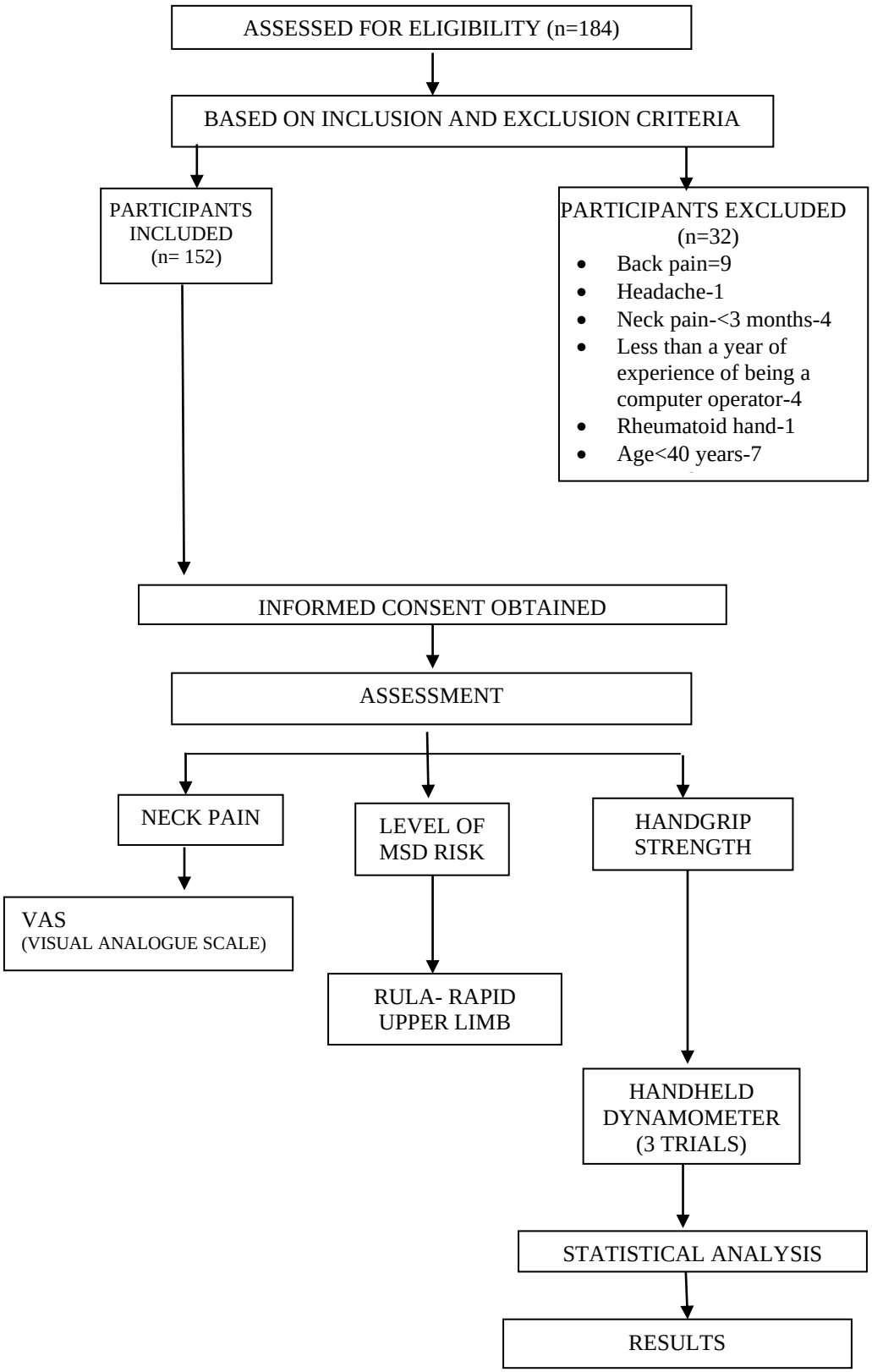
STUDY DURATION: 10 Months (during the period between February 08 2022 – December 05 2023)

PROCEDURE

152 Desktop workers with Neck Pain were taken based on the inclusion criteria from the Department of Orthopaedics, PSG hospitals. And informed consent was obtained from them. Neck pain was measured by using VAS. Level of MSD risk

was assessed by using RULA. And the Handgrip strength was measured for both the hands by using Handheld Dynamometer (HHD) for 3 trials. And finally, the Data was collected and analyzed using Spearman's rho (ρ) correlation coefficient.

METHODOLOGY FLOW CHART



STATISTICAL ANALYSIS

Data collected from subjects were assessed for normality by using skewness and kurtosis. As the data were not normally distributed, non-parametric analysis was conducted.

Descriptive analysis was used to find out the mean, standard deviation of VAS, RULA, handgrip strength of dominant hand among Desktop workers.

Spearman's rho (ρ)correlation coefficient was used to analyze the relationship between Neck pain, Level of MSD risk and Handgrip strength in Desktop workers. Correlation was considered as Very weak if r was 0.00-0.19, Weak if r was 0.20-0.39, Moderate if r was 0.40–0.59, Strong if r was 0.60-0.79 and very strong if r was 0.80-1.00.

Regression analysis was done to predict the value of a dependent variable (Neck pain) given values of 2 independent variables (RULA, Handgrip strength of dominant hand).

A value of $p<0.05$ was considered as significant. All analyses were performed using IBM SPSS Statistics version: 29.0

RESULTS

TABLE 1 DESCRIPTIVE STATISTICS OF STUDY PARTICIPANTS

VARIABLES	Mean ± SD	$Z_{skewness}$	$Z_{kurtosis}$
AGE (years)	31.17 ± 6.55	-0. 03	-3. 75
GENDER (Male/ Female)	63(41.4%) / 89(58.6%)	-1. 78	-4. 86
BMI (kg/m^2)	24.85 ± 4.48	2.86	2.46
YEARS OF EXPERIENCE	7.66 ± 6.18	3.91	-1. 14
VAS (cm)	6.30 ± 1.31	1.35	-1. 11
RULA	5.23 ± .92	-2. 41	-4. 23
HGS (kg)	22.16 ± 8.84	5.06	0.83

SD- Standard deviation, BMI- Body Mass Index, VAS- Visual analogue scale, RULA- Rapid upper limb assessment, HGS- Hand grip strength

For medium-sized samples ($50\leq n <300$), at absolute z-value ± 3.29, conclude the distribution of the sample was normal. From the table 1, BMI and VAS were normally distributed whereas, age, years of experience, RULA and HGS were not normally distributed.

TABLE 2 SPEARMAN'S RHO (ρ) CORRELATION MATRIX

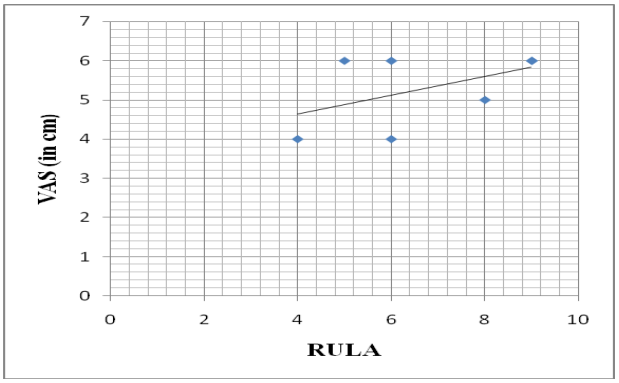
		VAS	RULA	HGS
VAS	Correlation coefficient	1.000	.576	-.429
	Sig. (2-tailed)	.	<.001	<.001
	n	152	152	152
RULA	Correlation coefficient	.576	1.000	-.351
	Sig. (2-tailed)	<.001*	.	<.001
	n	152	152	152
HGS	Correlation coefficient	-.429	-.351	1.000
	Sig. (2-tailed)	<.001*	<.001*	.
	n	152	152	152

Spearman's rank-order correlation was run to determine the relationship between 152 desktop workers' VAS, RULA and HGS values. From Table 2, there was a moderate, positive correlation between VAS and RULA, which was statistically significant ($r_s = .576$, $p = <.001$) (Graph 1).

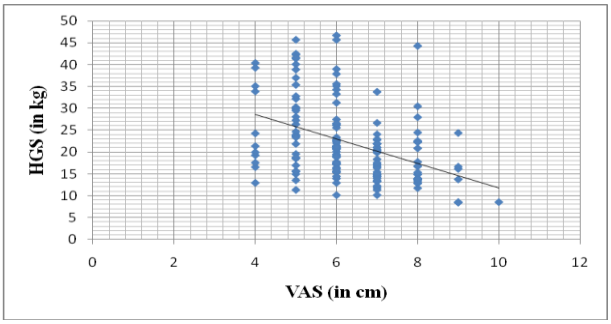
There was a moderate, negative correlation between VAS and HGS, which was statistically significant ($r_s = -.429$, $p = <.001$) (Graph 2).

There was a weak, negative correlation between RULA and HGS, which was statistically significant ($r_s = -. 351$, $p = <.001$) (Graph 3)

Graph 1: Scatter plot which estimates association between VAS and RULA in Desktop workers with chronic neck pain



Graph 2: Scatter plot which estimates association between VAS and HGS in Desktop workers with chronic neck pain



Graph 3: Scatter plot which estimates association between RULA and HGS in Desktop workers with chronic neck pain

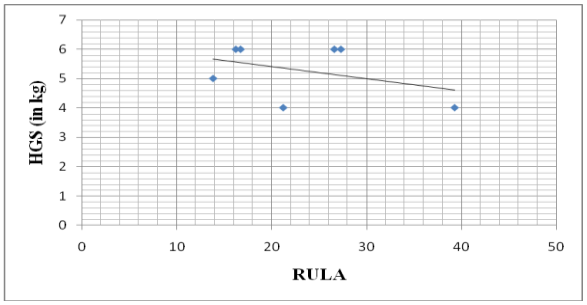


TABLE 3 MULTIPLE REGRESSION ANALYSIS

a. Model Summary			
R	**R^2**	**Adjusted R^2**	**Std. Error**
.603	.363	.355	1.049

b. ANOVA					
	Sum of squares	**df**	**Mean squares**	**F**	**Sig.**
Regression	93.588	2	46.794	.603	p < 0.05
Residual	164.090	149	1.101		
Total	257.678	151			

c. Coefficients					
	B	**SE**	**SC**	**t**	**Sig.**
(constant)	3.606	.643		5.606	p <0.05
RULA	.669	.099	.470	6.727	p <0.05
HGS	-.037	.010	-.247	-3.540	p <0.05

Predictors: Neck pain
Dependent variables: RULA, HGS

A multiple regression was run to predict Neck pain from RULA and HGS. Table 3 shows that, these variables statistically significantly predicted Neck pain, F (2,149) = .603, p < .001, R^2 = .363. All two variables added statistically significantly to the prediction, p < 0 .05.

DISCUSSION

The purpose of this study was to analyze the relationship between Neck pain, Level of Musculoskeletal disorders (MSD) risk and Hand grip strength in Desktop workers. In this study, 152 Desktop workers were included and 32 were excluded based on the inclusion and exclusion criteria.

Out of 152 desktop workers, 63 (41.4%) were males and 89(58.6%) were females. In age variable, 75 representing (49.4%) of the desktop workers were between the age of 20-30, 77 (50.6%) were between the age of 31-40. In the variable of BMI, 9 (6.0%) of the participants were underweight, 66 (43.4%) were normal, 61 (40.1%) were overweight, 16 (10.5%) were obese. 74(48.7%%) comes under 1-5 years of experience of being a computer operator, 33(21.7%) comes under 6-10 years of experience, 27 (17.8%) were under 11-15 years of experience, 16 (10.5%) were under 16-20 years of experience, 2(1.3%) were under 21-25 years of experience. Out of 152, 145(95.4%) were right dominant and 7(4.6%) were left dominant.

Neck pain in desktop workers is may be due to often holding the neck in a forward bent posture for prolonged time or often working in the same position for a prolonged time. This was supported by B. Cagnie et al (2007), suggested that an increased risk of neck pain for those who spent a high percentage of the working time with the neck at a minimum of 20 degree of flexion. [13]

Rapid Upper Limb Assessment (RULA) is a subjective observation method of posture analysis that focuses on the upper body, but includes the lower body. [19] Abnormal posture may be seen in Desktop workers due to their prolonged static position. Mechanism of this was supported by, B. Cagnie et al (2007), which says that static contraction of the trapezius and other shoulder muscles is needed to keep the arms at right angles, a necessary posture when using the keyboard. This contraction is accentuated when there is also rotation or bending of the neck when the computer screen is not placed at the right place. Thus, it attributes to changing muscle patterns to reflect more the subjects' personal habitual movements and postures rather than the influence of their workstations. [13]

The observed HGS was compared to the reference HGS for age groups and gender. The data's shown a decrease in HGS in some desktop workers. This can be explained by physiological adaptations to their working tasks, which implies that the long-term manual work with a certain force result in force-related adaptions within the muscular system[12].It was also found that abnormal repetitive movement or sustained static postures of the upper extremity, head and neck can negatively affect the nerves and other soft tissue structures in the upper quadrant resulting in arm and hand dysfunctions. [12]

In this study, Camry electronic handheld dynamometer was used to assess the handgrip strength in Desktop workers with elbow in fully extended position. It was supported by Mani, P., concluded that, the reliability of the electronic hand dynamometer for the right side with the elbow flexed was found to be 0.94 while for left side was found to be 0.91. Meanwhile, the reliability for the right side with elbow extended was found to be 0.98 and for the left side was 0.97. Test-retest reliability of the Camry electronic hand dynamometer showed excellent reliability and the scores were the best when the elbow was held in fully extended position during the testing procedure. [20]

This study shows that there was a relationship between VAS and RULA in desktop workers and it was statistically significant. And there was moderate correlation found between VAS and RULA

which means awkward working posture is moderately associated with neck pain. This result was supported by B. Cagnie et al (2007), revealed that neck pain was significantly associated with often holding the neck in a forward bent posture for a prolonged time, various short periods of movements with the neck, often working in the same position for a prolonged time, often making the same movements per minute, often sitting for a prolonged time and computer working time. [13]

It also shows that there was a relationship between VAS and HGS in desktop workers whichwas statistically significant. In analysing this relationship, Correlation coefficient obtained was -0.429 which is Moderate and negative in relation. This was supported by Mansi Bidja et al (2018), which shown the similar results, r=0.44 but it does not explain about the direction of relationship which has been clearly explained in this study. [9] HGS significantly decreases with chronic neck pain. This is due to, the Abnormality in sensory and motor neurons in neck pain leads to poor quality of sensory information that generate motor output. [11]

And this result of relationship was also supported by Dr. M. Gnanasekaran, BOT et al (2019) and Sakshi Jain et al (2018).

In Gnanasekaran, BOT et al (2019), compared the HGS with and without cervical pain among final year male and female dental students and it concluded that there was a significant relationship between the neck pain and the hand grip strength among final year and internship dental students, due to impact of poor ergonomics.[8]

In Sakshi Jain et al (2018), reported that cervical stability and movement control are crucial for arm and hand functions. The cervical proprioceptors have central and reflex connections to the vestibular and visual systems which is highly important for goal directed hand movements. The receptors in cervical spine have important connections to visual apparatus and dysfunction of these receptors can alter afferent input changing the integration of sensorimotor control which can further alter the oculomotor control; utmost important for the eye-hand coordination. [12]

This study also shows another relationship, i.e., between RULA and HGS in desktop workers and it was statistically significant. This result was supported by Sachin Etam et al (2019), assessed posture adapted by the bank workers and handgrip strength using RULA scale (Rapid Upper limb Assessment) and hand dynamometer and correlated them. The results shown negative correlation between the final RULA Score and hand grip strength which suggests that more the RULA score lesser is the hand grip strength [15]. The strength of the relationship between RULA and HGS in Sachin Etam et al (2019) was moderate whereas it has weak relation in this study. This may indicate that, some other variables may affect these variables.

The mechanism for a decrease in handgrip strength when RULA score increases was supported by Sachin Etam et al (2019), which says that the relation of scapulohumeral misalignment due to long static posture of arm in shoulder flexion and protraction with unsupported forearm in the work environment may be considered as a cause of mechanical disadvantage for the force production by the muscles of upper limb as a whole.[15]

With the obtained data we can evidently educate the desktop workers about the vulnerability towards various problems and to maintain the safety precautions for the patient and self. For this, Condition- and behaviour-orientated interventions are required to reduce neck pain and the risk of wrist dysfunction at manual repetitive handling workstations. The overall ergonomic setting of workstations should be improved to address reductions of HGS. The participants were recommended postural correction to reduce or minimize the risk of the development of work-related musculoskeletal disorders.

Thus, with the reference to the statistical analysis done from the collected data of Visual Analogue Scale, RULA and Hand grip strength shows a significant relationship between Neck Pain, Level of MSD risk and Handgrip strength in Desktop workers. Thus, proving the alternate hypothesis and rejecting the null hypothesis.

LIMITATIONS

- This study has not addressed about the individual and work-related risk factors for neck pain.
- This study has not taken the worker's postural deviations into the account.
- In some patients, after 1 trial of handgrip strength assessment, neck pain got aggravated which limited the outcome of handgrip strength.

SUGGESTIONS

- This study can be conducted on different professionals and on laptop workers
- Evaluation of neck pain, level of MSD risk and handgrip strength can be implemented in regular physiotherapy assessment
- Intervention based study can be done to see the effect of treating 3 parameters rather than treating a single parameter
- Future research may also focus on workstation evaluation to reduce mechanical and psychosocial risk factors.
- Other parameters (cranio-vertebral angle, scapular positions, shoulder pain, low back pain, balance, gait etc.,) can also be considered to correlate with RULA and Hand grip strength in the future research.
- Other tools can also be used to assess the level of musculoskeletal disorders.
- On regression analysis, 64% remains unexplained, i.e., some other variables may be influencing or predicting the neck pain, which can be studied in the future.
- In future studies, Bilateral HGS values can be analyzed with Neck pain and RULA

CONCLUSION

This study was conducted to analyse the relationship between Neck Pain, Level of MSD risk and Handgrip strength in Desktop workers. With the reference to the statistical analysis done from the collected data of Visual Analogue Scale, RULA and Hand grip strength shows a significant relationship between Neck Pain, Level of MSD risk and Handgrip strength in Desktop workers.

From this study it was found out that there is a Moderate and positive correlation between VAS and RULA, Moderate and negative correlation between VAS and handgrip strength, and Weak and negative correlation between the RULA Score and handgrip strength.

Declaration by Authors

Ethical Approval: Approved. The study was reviewed and approved by Institutional Human Ethics Committee at PSG IMSR, Coimbatore. (PSG/IHEC/2022/Appr/Exp/028)

Acknowledgement: With profound gratitude, I acknowledge the Lord almighty, my Parents, Guides, Faculties, Clinical staffs, IRB and Friends for their support and contributions to this research endeavor.

Source of Funding: None

Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

1. Chen CY, Lu SR, Yang SY, Liang FW, Wang JJ, Ho CH, Hsiao PC. Work-related musculoskeletal disorders among physical therapists in Taiwan. Medicine (Baltimore). 2022 Feb 18;101(7): e28885. doi:10.1097/MD.0000000000028885. PMID: 35363204; PMCID: PMC9282087.
2. Misailidou V, Malliou P, Beneka A, Karagiannidis A, Godolias G. Assessment of patients with neck pain: a review of definitions, selection criteria, and measurement tools. J Chiropr Med. 2010 Jun; 9(2):49-59. doi: 10.1016/j.jcm.2010.03.002. PMID: 21629550; PMCID: PMC2943658.
3. Aysha Siddiqua Kalim Khan, Mohammed Faizan. Neck pain in computer users. Panacea Journal of Medical Sciences. May-August,2016; 6(2): 88-9
4. Green BN. A literature review of neck pain associated with computer use: public health implications. J Can Chiropr Assoc. 2008

Aug;52(3):161-7. PMID: 18769599; PMCID: PMC2528269.
5. Alagingi NK. Chronic neck pain and postural rehabilitation: A literature review. J Bodyw Mov Ther. 2022 Oct; 32:201-206. doi: 10.1016/j.jbmt.2022.04.017. Epub 2022 Apr 20. PMID: 36180150.
6. Sneha Hiren Bhalala. Prevalence of Neck Pain in Computer Workers in Surat City: A Cross-sectional Study. International Journal of Current Research and Review. 2019 October; 11(20)
7. Faiza Sabeen, Muhammad Salman Bashir, Syed Imtiaz Hussain, Sarah Ehsan. Prevalence of Neck Pain in Computer Users. Annals. April – June 2013; 19(2)
8. Gnanasekaran, D.M., & Sonavane, D.J. To Assess the Relationship between the Neck Pain and Hand Grip Strength in Final Year and Internship under Graduate Dental Students, due to the Impact of Poor Ergonomics. International Journal of Science and Research (IJSR). April 2019; 8(4)
9. Bidja, D.M., Mishra, D.N., & Mishra, D.A. A Study on correlation between neck pain and handgrip strength and its effect on QoL among female beauticians. International Journal of Research and Analytical Reviews. July- Sept 2018; 5(3).
10. Bettina Wollesen, Julia Graf, Nils Schumacher,Gianluca Meyer, Matthias Wanstrath, Christian Feldhaus, Kerstin Luedtke, Klaus Mattes. Influences of Neck and/or Wrist Pain on Hand Grip Strength of Industrial Quality Proofing Worker. Safety and Health at Work. 2020 December; Volume 11, Issue 4, Pages 458-465.
11. Vanita Ramdati and Neela Soni. The correlation between Chronic Neck pain and Hand grip Strength in Dentists of Gujarat. International Journal of Current Advanced Research. September 2019; Volume 8; Issue 09 (E); Page No.20027-20029
12. Sakshi Jain, Shambhavi Sharma. Correlation of Neck Posture with Hand Function in Computer Professionals. Journal of Medical Science and Clinical Research. June 2018; Volume 06 Issue 06.
13. 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 May;16(5):679-86. doi:10.1007/s00586-006-0269-7. Epub 2006 Dec 8. PMID: 17160393; PMCID: PMC2213555.PMC2213555
14. Nair, P., Nambiar, V., Verma, S., & Ravindra, S. Correlation between Hand Grip Strength, and Duration in Computer Operators. Indian Journal of Physiotherapy & Occupational Therapy-An International Journal, Oct-Dec2012; Vol. 6 Issue 4, p137-141.
15. Sachin Etam, Tanvi Parab. A Correlational Study of Grip Strength Using Handheld Dynamometer and Rapid Upper Limb Assessment Score in Asymptomatic Bank Employees. Indian Journal of Physiotherapy and Occupational Therapy. January 2019; 13(4):148.
16. McAtamney L, Nigel Corlett E. RULA: a survey method for the investigation of work-related upper limb disorders. Appl Ergon. 1993 Apr;24(2):91-9. doi:10.1016/0003-6870(93)90080-s. PMID: 15676903.
17. Alperovitch-Najenson D, Carmeli E, Coleman R, Ring H. Handgrip strength as a diagnostic tool in work-related upper extremity musculoskeletal disorders in women. ScientificWorldJournal. 2004 Mar 3; 4:111-7. doi:10.1100/tsw.2004.12. PMID: 15010565; PMCID: PMC5956401.
18. Rostamzadeh S, Saremi M, Fereshteh T. Maximum handgrip strength as a function of type of work and hand-forearm dimensions. Work. 2020;65(3):679-687. doi:10.3233/WOR-203100. PMID: 32116266.
19. Dockrell S, O'Grady E, Bennett K, Mullarkey C, Mc Connell R, Ruddy R, Twomey S, Flannery C. An investigation of the reliability of Rapid Upper Limb Assessment (RULA) as a method of assessment of children's computing posture. Appl Ergon. 2012 May; 43(3):632-6. doi: 10.1016/j.apergo.2011.09.009. Epub 2011
20. Mani, P. Test-Retest reliability of electronic hand Dynamometer in healthy adults. International Journal of Advanced Research. May 2019; 7(5):325-331.

How to cite this article: Kiruthika S, R. Mahesh, Indhu R. A correlation study to analyze the relationship between neck pain, level of musculoskeletal disorders (MSDs) risk and handgrip strength in desktop workers. *Int J Health Sci Res.* 2024; 14(8):37-46. DOI: *https://doi.org/10.52403/ijhsr.20240806*

******