IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 16, Issue 5 Ser. II (Sep. - Oct. 2019), PP 12-18
www.iosrjournals.org

Ergonomic Assessment of Secondary Task Performed by Indian Railways Loco Pilots

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Abstract: *The major part of Indian economy depends on Indian Railways, ran by 1.27 million employees working round the clock, of which locomotive pilots are most responsible category of employee engaged in operation directly. But the segment susceptible to belonging from work related musculoskeletal disorder due to working environment and driving postures. It is therefore the secondary driving activities performed by the loco pilots are evaluated using Rapid Upper Limb Assessment (RULA) method with an objective to find out the risk associated with it. The study also aiming to find out the possibility of reduction or elimination of those activities in the present scenario to facilitate loco pilots, if feasible. RULA score revealed that all the secondary activities are mostly belong to action level two.*

Date of Submission: 09-09-2019 Date of Acceptance: 25-09-2019

I. Introduction

Indian Railways (IR) is one of the world's largest rail network with 68,442 km of route lengths as on 31 March, 2018. It is the most commonly used mode of public transportation in the country, carried 8,286 million passengers during 2017-18. Also it handled 1159.55 tonnes of freight traffic in the same financial year [1].

The revenue earning in freight traffic of Indian Railways picking up due to stepped-up movement in coal, fertiliser, iron ore and cements etc., thus the railways is critical for India's Gross Domestic Product (GDP) [2].

This is only been possible due to the efforts of 12,70,715 numbers of regular employee (as on 31.03.2018), including locomotive pilots working round the clock [1].

Loco Pilots are working in locomotive under extreme weather conditions of heat, humidity and dust prevalent across the country [1]. The driving posture also may affect their health status, as electric loco pilots are susceptible to musculoskeletal disorders, lead to de-categorization and low retirement age.

A sample of 29 electric goods loco pilots, driving in standing/sitting postures was studied. This driving posture is broadly classified into two categories, (i) Primary Functions, i.e. essential to operate the moving giant; and (ii) Secondary Functions, additional activity for smooth running of train. The present study is focused on this secondary function only.

The secondary function is further sub-divided into five elementary activities, e.g. talking in walky-talky, signal exchange, etc. The results finally evaluated by using Rapid Upper Limb Assessment (RULA) method, a tool to assess the loads sustained by the musculoskeletal system [3].

The working condition of railway drivers are quite hard, required high alertness, stamina, ability to work in adverse condition [4]. The nature of their work also considered extremely stressful, may lead to fatigue and increases the chances of accident [5].

Massaccesi et al. (2003) found significant association between RULA scores and self-reported discomfort on truck driver's neck and trunk region [6].

Balaji et al. (2015) discovered that as per RULA score most of the existing excavator drivers are belonging to moderate to high level health hazard, especially on wrist, upper arm and trunk region [7].

Yasobant et al. (2015) conducted a study to find out work-related musculoskeletal disorders, especially on low back and neck region on professional bus drivers and RULA scores suggest ergonomic intervention for modification of workstation and working style is essential [8].

Mahfudh et al. conducted an ergonomic assessment to find out musculoskeletal disorder among armoured personnel carrier (APC) driver, and RULA score indicates moderate level of risk associated with it [9].

Lee et al. (2014) conducted a study to evaluate musculoskeletal symptoms, pain and risk of postures as well as the effects of stretching exercise on the work-related symptoms and found that performing stretching for musculoskeletal symptoms had a positive influence to reduced pain [10].

The objective of this study is to identify work-related musculoskeletal disorders due to secondary functions and necessity of those activities in present scenario, as reduction or elimination of such activity may bring little bit relief on the work load of loco pilots.

II. Material And Methods

In this present ergonomic study, only WAG_7 old variant locomotives were considered. It is the most economical, affordable and successful variant of goods locomotive with 5000 hp hauling capacity. It is designed indigenous by The Research Designs & Standards Organisation (RDSO) and built either in Chittaranjan Locomotive Works (CLW) or Bharat Heavy Electricals Limited (BHEL). All BHEL built WAG_7 locomotives have Tiger Face colours, i.e. Red or Dark Blue on white. But CLW built WAG_7 locomotives have yellow stripe on blue colour. On 3 August 1992, the first WAG_7 locomotive was inaugurated and named *Shantidan* in honor of *Mother Teresa* [11]. In the 2015–16 financial year, these type of loco production was totally stopped in CLW.

Twenty nine male electric goods loco pilots were considered for the present study and all of them participated voluntarily.

The study is focused on few frequently adopted secondary functions only. These are those activities which are not essential to operate the moving giant, but to assist for smoother functioning of locomotive.

The secondary functions are sub-divided as –

(i) Blowing horn – to make alert about the moving giant,
(ii) Operating vigilance switch – to feed awakening signal to loco control,
(iii) Use of walky-talky – to exchange verbal communication,
(iv) Signal exchange – to exchange speech-less communication, and
(v) Leaning out – to check the following train attached at the rear end visually.

During analysis, the worst postures were identified and evaluated by using Rapid Upper Limb Assessment (RULA). This indexing method is used to identify the tasks and body segment associated with highest potential of risk.

Rapid Upper Limb Assessment (RULA) is a survey method developed by McAtamney et at. (1993), and used for ergonomics investigations of workplaces those are subjected to work-related upper limb disorders. This is a quick assessment tool, requires no special equipment to assess the neck, trunk and upper limbs postures along with muscle function and external loads on body. Ultimately a coding system is used to indicate the action level, which further suggests the potential of risk associated with the work and ergonomic intervention required or not [3].

To carry out appropriate statistics on collected data and unbiased analysis of outcomes, excel software was utilized. The statistical results also been verified by using basic formulations available in standard textbook [12].

III. Result

The secondary functions during locomotive driving of 29 male electric loco goods pilots were measured in the present study. All the subjects were chosen randomly and participated voluntarily. As the secondary functions contain five sub-sections, hence one by one elaboration is made as under –

a) Application of Horn

The details of RULA scoring during application of horn and suggested action level is listed below in tabular form –

Table no. 1: RULA Scores during Application of Horn.

Score	Posture Score A	Wrist & Arm Score	Posture Score B	Neck, Trunk & Leg Score	RULA Score	Action Level	Total Population
1	0	0	19	19	0	1	1
2	2	2	2	2	1		
3	14	14	5	5	25	2	25
4	10	10	0	0	0		
Mode	3	3	1	1	3	-	2

The graphical representations of the same is depicted below –

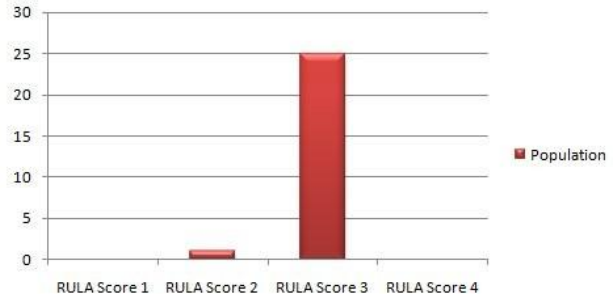


Figure 1. Graphical representation of RULA Score during Application of Horn
Figure 2. Graphical representation of Priority for Change as suggested by RULA

During application of horn only one person is having safe working posture with action level of 1. The remaining population belonging to action level 2 may need few changes either in body posture or horn lever design.

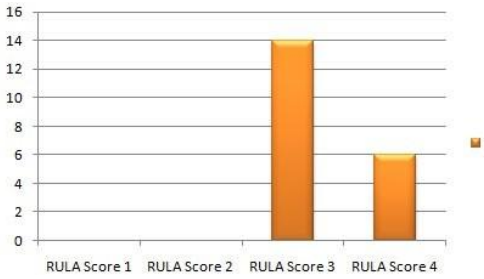
b) Operating Vigilance Switch

The details of RULA score during operating vigilance switch and suggested action level is furnished below –

Table no. 2: RULA Scores during Operating Vigilance Switch.

Score	Posture Score A	Wrist & Arm Score	Posture Score B	Neck, Trunk & Leg Score	RULA Score	Action Level	Total Population
1	5	5	0	0	0	1	0
2	5	5	0	0	0		
3	9	9	20	14	14	2	20
4	1	1	0	6	6		
Mode	3	3	3	3	3	-	2

The graphical representations of operating vigilance switch is represented below –



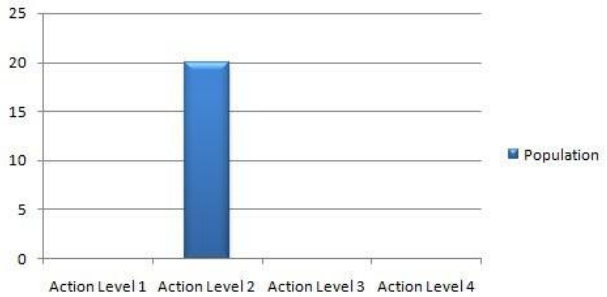


Figure 3. Graphical representation of RULA Score during Operating Vigilance Switch
Figure 4. Graphical representation of Priority for Change as suggested by RULA

During operating vigilance switch, all the populations are having action level two, means few corrections in body posture or vigilance switch may require.

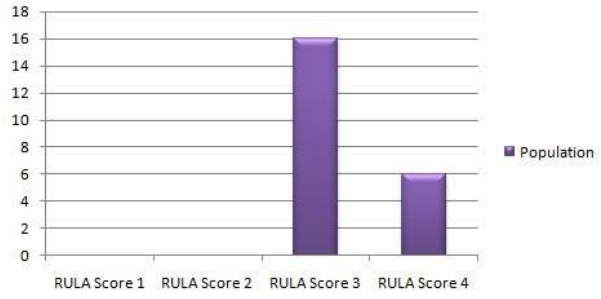
c) Using of Walky-talky

The details of RULA score during the use of Walky-talky and suggested action level is –

Table no. 3: RULA Scores during use of Walky-talky.

Score	Posture Score A	Wrist & Arm Score	Posture Score B	Neck, Trunk & Leg Score	RULA Score	Action Level	Total Population
1	0	0	11	11	0	1	0
2	4	0	3	3	0		
3	13	4	7	7	16	2	22
4	5	13	1	1	6		
5	0	5	0	0	0	-	-
Mode	3	4	1	1	3	-	2

The graphical representations of the same is as represented below –



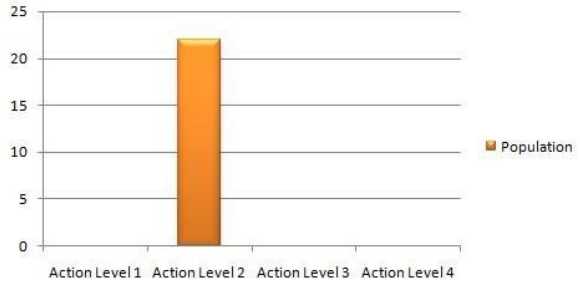


Figure 5. Graphical representation of RULA Score during use of Walky-talky
Figure 6. Graphical representation of Priority for Change as suggested by RULA

Same as previous, all the population is having suggested action level of two during the use of Walky-talky.

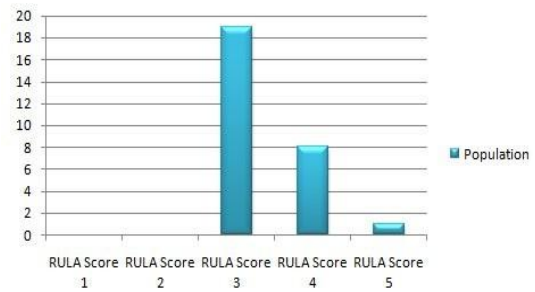
d) Signal Exchange

As previous the details of RULA score during signal exchange and suggested action level is represented below in tabular form –

Table no. 4: RULA Scores during Signal Exchange.

Score	Posture Score A	Wrist & Arm Score	Posture Score B	Neck, Trunk & Leg Score	RULA Score	Action Level	Total Population
1	0	0	2	2	0	1	0
2	0	0	20	20	0		
3	0	0	6	6	19	2	27
4	21	19	0	0	8		
5	5	7	0	0	1	3	1
6	2	2	0	0	0		
Mode	4	4	2	2	3	-	2

The graphical representations of signal exchange is depicted below –



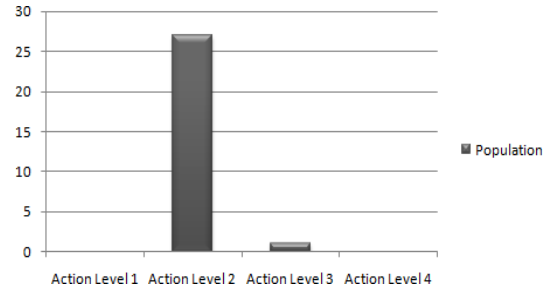


Figure 7. Graphical representation of RULA Score during Signal Exchange
Figure 8. Graphical representation of Priority for Change as suggested by RULA

During signal exchange only one person is having action level three, otherwise, the mode value is belonging to action level two.

e) Leaning Out

The details of RULA scoring during leaning out and suggested action level is as under –

Table no. 5: RULA Scores during Leaning Out.

Score	Posture Score A	Wrist & Arm Score	Posture Score B	Neck, Trunk & Leg Score	RULA Score	Action Level	Total Population
1	0	0	0	0	0	1	3
2	7	7	9	9	3		
3	10	10	10	10	16	2	17
4	3	3	1	1	1		
Mode	3	3	3	3	3	-	2

The graphical representations of leaning out is represented below –

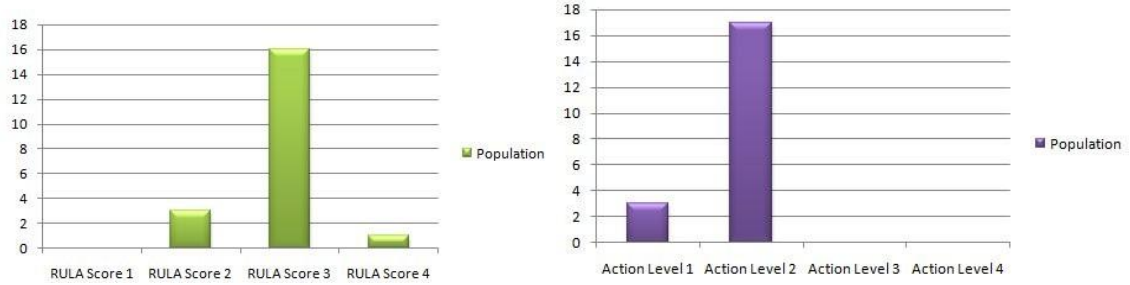


Figure 9. Graphical representation of RULA Score during Leaning Out
Figure 10. Graphical representation of Priority for Change as suggested by RULA

During leaning out only three people is having safe working posture with action level 1 and the remaining population belonging to action level 2, may need few changes in body posture.

IV. Discussion

Blowing horn is a secondary activity, needs to press horn lever in vertically downward direction by using left hand mainly. As it is a safety device to alert all about the upcoming moving giant, therefore not possible to eliminate.

The RULA score suggest, during application of horn only one person is having safe working posture with action level of 1 and the remaining other possesses action level 2.

The elaboration of RULA scoring system indicates that the posture score A for most of the population is either 3 or 4 with a mode value of 3. This indicates that the problem is associated with upper limb. Prevention of wrist bending during application of horn may bring the situation under control.

The vigilance is a foot switch, need to operate minimum once in a minute during loco running. It is also a safety device, provides feed to the locomotive control about the awakening condition of loco pilot. During running, if that switch is not pressed within one minute of time, the loco brake will operate and stop the train automatically.

The RULA score indicates all the populations are belonging to action level two during operating vigilance switch.

The elaboration of RULA scoring system indicates that the posture score B for all the subjects are having mode value of 3. As it is a foot switch, prevent balanced support of legs, create worsening of posture. In few cases, the excess repetition of the task makes the situation harsher.

The walky-talky is used for verbal communications with other employees engaged in direct rail operation. Same as previous, the RULA score indicates that all the populations are having action level of two.

The elaboration of RULA scoring system pointed out that the mode value of posture score A is 3 and wrist and arm score is 4. Due to keeping the walky-talky at shoulder height during use, increase of lower arm score is observed. Also few subjects deviate or twist their wrist causes increase in wrist score. Moreover, the shifting of upper limb mode value from 3 to 4 indicated the weight of the walky-talky, which is approximately 4 kg, are responsible for increase in force/ load score. Use of walky-talky keeping it on driving desk and prevention of wrist bending during its use may reduce the RULA score.

Signal exchange is a speechless communications with the railway employees directly engaged with the train movement. The loco pilots shows green / red flag to those employee on day time and same coloured light at night to indicate the absence of abnormality or any danger in the route. The employees like guard, station master, gateman etc. also exchange the signal by showing the same coloured flag or light.

During signal exchange only one person is having action level three; otherwise, the mode value is action level two.

Due to abducted upper arm, obtuse angle between upper and lower arm, arm positioned out to side of body, originally makes the upper limb RULA score high, which is reflected with mode value of 4 in posture score A. Moreover deviated wrist and protruding the flag beyond the window cause more worsening of the situation, as the air blast increases the force/ load score of upper limb, as observed in two cases of wrist and arm score from table.

In leaning out posture, the loco pilots are watching the following train attached to the rear end of the locomotive. It is performed to search any abnormality in following train. Though the activity is essential for train's safety, but not acceptable as safety of loco pilot is violated. Though the RULA score of this activity specify the posture is little bit risky with mode value of action level is two, but that actually not reveal the original situation. During the train's movement in forward direction at high speed, the loco pilots lean outside

keeping their head in the rear end to observe the train. In that situation, if any foreign body or even a small flying bard strike on his heat, it will hit like a bullet, may cause fatal accident, thus the posture not at all safe. Also there is a probability of fallen down from the locomotive by slipping.

V. Conclusion

Train driving is a complex task with higher level of decision-making and dynamic control operation [19].
The information of surroundings needs to be identified, processed, and used to take appropriate actions.
Rapid Upper Limb Assessment (RULA) method is utilised to evaluate certain body or working posture and suggest potential of risk. Based on the risk level, the RULA suggest the priority of changes [3].
The present study is conducted on few frequently adopted secondary driving postures, sub-divided into five elementary activities, which are evaluated by RULA.
Results revealed all the activities are mainly belonging to action level 2, means ergonomic intervention may require. With this in view, the following modifications are suggested as per present Indian scenario –

(i) Instead of horizontally operated horn lever, vertically operated lever is suggested, which certainly improve the effort score by preventing wrist deviation.
(ii) It has been observed that the loco pilots are continuously keeping their hand on notch wheel. It is therefore suggested to re-locate the horn at the centre of the notch wheel, as commonly used at the centre of the steering wheel of cars. This certainly improves the posture with reduction in reaction time (as it is a safety device) with economic price.
(iii) A platform of 2 to 3 inch height is needs to be provided in locomotive and the vigilance switch needs to be located exactly at the same height in front of that platform, so that the loco pilot does not adopt any awkward posture to operate it.
(iv) Though the vigilance switch is a safety device, but in the age of modern era of technology, the necessity of this device to monitor the awakening condition of loco pilot is needs to be considered deeply. The repeated and excess application (mostly seen) of this device may cause musculoskeletal problem in long run. It is therefore, instead of vigilance switch, a camera with eyeball detector sensor and buzzer system need to be installed in front of loco pilots. This will certainly reduce an activity at a very low price, prevents the distraction during driving.
(v) Instead of providing walky-talky to each loco pilot, the in-built communication system may be installed on locomotive at a very reasonable price. The in-built communication system is already provided in EMU cabs for verbal communication of motor man and guard. The implementation of more advanced communication system obviously makes the situation more crew friendly.
(vi) The signal exchange with green or red flag and light is quite out dated now. Instead of that, a few coloured LED lamps need to be installed at locomotives corner wall, the location of the same should be same as car's indicator lamp and needs to operate by a switch, placed nearer to loco pilot. The implementation of such changes hardly required additional fund, as the modification may be readily carried out with present resources available at various electric loco sheds and workshops. The adaptation of this will certainly improve the speechless communication with elimination of awkward posture.
(vii) By installing surveillance camera at critical points of the train and providing display unit to train's guard, the leaning out activity can be eliminated. The commissioning of such system is economic now a days, but will be more effective even at night also

All the proposed modifications can be adopted easily and economically, proper adaptation will certainly make the driving as a pleaser task. But before its implementation, the opinion of end user is very much essential.

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