CHAPTER 2

REVIEW OF LITERATURE

2.1 INTRODUCTION

The basic requirement of any research is the units of theory, which should be defined with sufficient clarity to enable the researcher to proceed. A comprehensive review of literature is an integral part of any research endeavor, as it helps to identify the gap in research and aids the investigator in designing and analyzing research work. It also provides basis for interpretation and discussion of findings. Further, an acquaintance with earlier related studies is necessary to formulate appropriate research methodology. Keeping in mind the objectives set forth for the study, an attempt has been made in this chapter to review the available literature, which has meaningful relevance to the research.

There are numerous studies reported in the literature that support the notion that lower back disorder is indeed a significant problem. The reviewed literatures considers the problem from a number of perspectives, the wider environmental, social and physiological factors associated with these disorders, methods for assessing risks in the workplace and contemporary approaches for establishing effective ergonomics interventions. A thorough literature review helped in identifying the relevant LBD variables.
2.2 STUDIES RELATING TO LBD PREVALENCE AMONG VEHICLE DRIVERS

An early study by Village et al (1989) investigating whole body vibration (WBV) levels in underground load-haul-dump (LHD) vehicles was the first to reveal the potential hazards relating to WBV during the operation of large earth moving mining equipment. In this study, WBV was measured at the seat level during various operational tasks. In total, 22 measurements were made on 11 different LHD vehicles. The results indicated that 20 of the 22 measurements exceeded the ISO 2631-1 (1985) recommended limits in the vertical (z-axis) direction. Additionally, when the accelerations in all three orthogonal axes were combined, the ISO limits were exceeded in all 22 cases.

Anderson (1992) reported for a sample of motor coach company workers that 66.4% of the bus drivers experienced Low Back Pain (LBP) compared to 44.8% of the non-drivers and that most of these persons experienced mild pain (i.e., not interfering with work or customary levels of activity). Indeed, the drivers were found to suffer more from postural syndromes (involving no true anatomical abnormality and correctable by a simple change in posture/movement) than mechanical disorders (associated with definite injury of the musculoskeletal system).

Bovenzi & Zadini (1992) investigated the prevalence of self-reported low back symptoms by a postal questionnaire in a group of 234 urban bus drivers exposed to whole-body vibration and postural stress and in a control group of 125 maintenance workers employed at the same bus municipal company. After controlling for potential confounders, the prevalence odds ratios for the bus drivers compared to the controls significantly exceeded 1 for several types of low back symptoms (leg pain, acute low back pain, and low back pain). The highest prevalence of disc protrusion was found among the bus drivers with more severe whole-body
vibration exposure. Frequent awkward postures at work were also related to some types of low back symptoms. The average vertical whole-body vibration magnitude measured on the seat pan of the buses was 0.4 m/s², which is lower than the lower limit of health caution zone value (lower limit of the health caution zone is 0.45m/s²). The findings of this study also indicated that among the bus drivers low back symptoms occurred at whole-body vibration exposure levels that were lower than the health-based exposure limits proposed by the International Standard ISO 2631-1.

In a study of LBP risk in agricultural tractor drivers, Bovenzi & Betta (1994) found that vibration exposure and perceived postural load contributed independently to the increased risk for LBP. Workers in the group with the highest exposure to WBV and postural load had a three-fold increase in LBP prevalence, compared to the group in the lowest WBV and postural load category. Moreover, the odds ratios for the combined effect of total vibration dose in years and postural load (mild, moderate, hard, very hard) were examined (after adjusting for age, body mass index, education, sport activity, car driving, marital status, mental stress, climatic conditions, and back trauma). The highest odds ratio (4.58) occurred for the highest level of total vibration dose (40 years m²/s⁴) and postural load (very hard), whereas the odds ratio associated with the lowest vibration dose (5 years m²/s⁴) and lowest postural load (mild) was only 1.29. Interestingly, the odds ratio associated with the lowest postural load (mild) and the highest total vibration dose (40 years m²/s⁴) was found to be 3.29.
identified a significant increase in the likelihood of low back symptoms with an increase in total tractor driving hours.

Magnusson et al (1996) reported 60.0% prevalence of LBP for the group of American and Swedish bus drivers, which required on average, 18 days of sick leave period. Compared to a complementary group of truck and sedentary workers, the bus drivers experienced far more mild episodes of back pain than non drivers.

Krause et al (1997) carried out a cross-sectional study of 1449 urban transit workers. Drivers in the highest category for self-reported ergonomic risk factors had a four-fold increased risk of developing back/neck pain. The contribution was highly significant as the odds ratio associated with greater than 10 years of driving exposure was reduced to 2.55 from 3.43 when ergonomic risk factors were included in the multivariate analysis.

Kumar et al (2001) evaluated the effect of whole-body vibrations on degenerative changes in the spine of 50 tractor-driving farmers by comparing them with a control group of 50 non-tractor-driving farmers matched for age, sex, ethnic group, land holding and work routine. All participants were interviewed in detail for occurrence of low back pain, examined clinically and a magnetic resonance image (MRI) of the lumbar spine region was obtained. Evaluation of data revealed that the tractor-driving farmers complain of backache more often than non-tractor-driving farmers but there was no significant objective difference in clinical or magnetic resonance imaging between the two groups.

Bovenzi & colleagues (2002) examined the association between low back disorders, WBV exposure and perceived postural load amongst straddle carrier drivers, fork-lift operators, crane operators and a control group of port maintenance workers. These authors reported a significantly higher
12-month prevalence rate of low back symptoms among fork-lift operators who had the highest WBV exposure level and postural loading stress, when compared to a non-exposed control group.

An exploratory study by Cann et al (2004b) investigating WBV exposure and dose in the construction industry involved measurements from 67 vehicles representing 14 different types of heavy equipment. The findings indicated that operators of haulage truck vehicles were exposed to WBV in excess of ISO 2631-1 health limits for 8 hrs of daily exposure.

Kumar (2004) measured WBV exposure during the operation of heavy haulage trucks to determine if ISO 2631-1 standards were exceeded. Measurements were made on 240 ton (n = 2) and 320 ton (n = 2) haulage trucks during various work phases. The wRMS (weighted Root Mean Square) vibration acceleration in the z-axis (vertical direction) ranged between 0.30 and 2.72 ms$^{-2}$ (lower limit $< 0.45$ ms$^{-2}$ and upper limit $> 0.9$ ms$^{-2}$). Unloaded travel was associated with the highest vibration accelerations followed by loaded travel, loading, and dumping respectively. The investigator concluded that speed of travel and driving terrain had a great affect on the magnitude of the vibration exposure and that the decreased vehicle mass and increased driving speeds associated with unloaded travel contribute to the high vibration accelerations.

In a study conducted by Johanning et al (2006) assessed the US locomotive operator related and ergonomic seating design factors that may have confounding or mitigating influence on WBV exposure, shocks and its effects. Vibration exposure was measured according to international guidelines (ISO 2631-1; 1997). The calculated SEAT ratios (floor/seat transfer function) indicated that the seats magnified the floor input vibration, particularly in the horizontal directions. Almost all of the calculated Crest Factor (CF), Maximum Transient Vibration Value (MTVV) and Vibration
Dose Value (VDV) values were above the critical ratios given in ISO 2631-1, which suggested that relatively high and frequent irregular shocks on the seat level were common throughout routine work cycles. Railroad engineers rated their seats mostly unacceptable regarding different adjustment and comfort aspects (3.02–3.51; scale 1=excellent to 4=unacceptable), while the control group rated their chairs more favorably (1.96–3.44). In a logistic regression analysis, time at work being bothered by vibration (h/day) was significantly associated with an increased risk of low back pain, shoulder and neck pain, and sciatic pain among railroad engineers. Existing cab and seat design in locomotives can result in prolonged forced awkward spinal posture of the operator combined with WBV exposure. The prevalence of serious neck and lower back disorders among locomotive engineers was found to be nearly double that of the sedentary control group without such exposure. Similar results were found for North-American railroad (RR) engineers by Johanning et al (2004), although the basic vibration levels appear to be lower compared to some road and off-road vehicles with high vibrations levels and back disorder risks [(Hulshof & Zanten 1987) and (Bovenzi & Hulshof 1999)]. Helicopter operators with relatively low and similar vibration levels as described in the rail bound vehicles (locomotives) were also found to have a high rate of back disorders, possibly due to combined effects of vibration and forced awkward spinal posture (asymmetric) because of seat and cab design features [(Hulshof & Zanten 1987), (Lopez-Lopez et al 2001), (Colak et al 1992) & (Froom et al 1984)].

In a cross-sectional study conducted by Hagberg et al (2006) in Sweden found that exposure to whole body vibration (WBV) was prevalent among agricultural, forestry, fishery workers and among plant and machinery operators based on a sample of 40,000 employed persons. Approximately, 9798 persons answered both the interview and the questionnaire for the analysis of exposure–response. Exposure to WBV at least half the working
time was associated with prevalence ratios above two for musculoskeletal symptoms in the low back, neck, shoulder/arm and hand among workers. When the exposure factors lifting and frequent bending were added to a multivariate analysis, surprisingly the magnitude of association was low between low back symptoms and WBV exposure. Interestingly, the relation between WBV exposure and symptoms in the neck, shoulder/arm and hand had the same or higher magnitude of association even when the possible confounders were in the model. For the neck, low back and shoulder/arm there was a visible increase in prevalence ratio (as high as 5 times) when combined exposures of WBV, lifting, frequent bending, twisted posture and noise were included in the analysis.

Okunribido et al (2007) has conducted a cross sectional study to investigate worker exposure to posture demands, Manual Materials Handling (MMH) and whole body vibration as risks for low back pain (LBP). Using validated questionnaire, information about driving experience, driving (sitting) posture MMH, and health history was obtained from 80 city bus drivers. Twelve drivers were observed during their service route driving (at least one complete round trip) and vibration measurements were obtained at the seat and according to the recommendations of ISO 2631 (1997), for three models of bus (a mini-bus, a single-decker bus, a double-decker bus). The results showed that city bus drivers spend about 60% of the daily work time actually driving, often with the torso straight or unsupported, perform occasional and light MMH, and experience discomforting shock/jerking vibration events. Transient and mild LBP (not likely to interfere with work or customary levels of activity) was found to be prevalent among the drivers and a need for ergonomic evaluation of the drivers’ seat was suggested.

Birlik (2009) assessed Whole body vibration exposure of the train drivers working for State Railway Lines by referring to ISO standard 2631 -1
and EU directive 2002/44/EC. The vibration measurements were done in the cabins of suburban and intercity train drivers. Suburban train driver performs his job usually in standing posture. Whereas intercity train driver works generally in seated (bending forward) posture and exposed to longer periods of continuous vibration, compared to suburban train drivers. Daily exposure action values suggested in EU directive are exceeded in case of intercity train drivers and their exposure falls within the health caution zone of ISO 2631-1.

Smets et al (2010) measured Whole body vibration (WBV) on eight surface haulage trucks in three size classes (35, 100, 150 ton haul capacities). Vibration was measured at the seat/operator interface in accordance with the ISO 2631-1 standard. Assessment was carried out using ISO 2631-1 and 2631-5. Operators of surface haulage trucks are regularly exposed to WBV levels that exceed safety limits as dictated by the ISO 2631-1 standard. However, according to ISO 2631-5 the probability of an adverse health effect remains low. Authors surveyed the Equipment operators of haulage trucks with a categorical questionnaire to gather information on anthropometrics, work experience, and any existing musculoskeletal disorders. Discomfort in various body regions was rated by the operator on a 4-point scale ranging from mild (score of 1) to very severe (score of 4). The Musculoskeletal discomfort associated with vehicle operation, 14% of operators reported neck pain of moderate severity, 14% reported upper back pain of mild severity, 29% reported low back pain of moderate severity, and 14% reported knee pain of moderate severity.

Stephan et al (2010) carried out a spinal pain survey among New Zealand farmers and found low back pain was the most commonly reported complaint for both 7 day (50%) and 12 month prevalence (67%), followed by the neck (17% and 42%) and the upper back (17% and 25%) respectively. This is consistent with the high prevalence of low back pain and
musculoskeletal disorders observed in occupations using ATVs [(Firth et al 2002), (Rehn et al 2002) and (Walker-Bone & Palmer 2002)]. It was concluded that as the shock doses for these farmers were low, it is more likely that the high doses of WBV, and not shock are the risk factor for the development of low back pain. Other factors such as the sustained flexed and seated postures used while driving the ATV, and frequent heavy-lifting work tasks associated with farming and often taken in series with ATV riding, are also likely to account for the high prevalence of low back pain among farmers. Bovenzi & Hulshof (1998) in their work on tractor drivers have shown that in the first 4 yr the prevalence odd ratio for back pain did not change with respect to WBV dose, whereas thereafter a linear relationship was observed. The slope after 10 yr was much steeper compared to 4–10 yr range. Schwarze et al (1998) has noted that posture dominant period coincides with 30–40 yr of age which is considered to be most crucial for developing lumbar degenerations due to vibration.

2.3 RESEARCH GAP

The foregoing literature review indicates that there are only few Indian studies available on environmental ergonomic risk factors and LBD prevalence. Further, there is only little or no research to the best of our knowledge in the previous research which established the relationship between environmental ergonomic risk factors, LBD prevalence, Prevention of activities and Medical Intervention for LBD. Earlier researchers have studied the influence of single or few risk factors on LBD. Impact of combination of several environmental ergonomic risk factors and LBD prevalence model for testing LBD prevalence among drivers is lagging. Study on environmental ergonomic risk factors among drivers and testing whether type of occupation (driving and office work), individual conditions like age, income, educational qualification, body mass index, exercising habit, smoking, chewing pan/tobacco, drinking alcoholic beverages habit, type of
vehicle and also type of suspension provided in the vehicle having relationship with LBD prevalence, prevention of activities and medical intervention among drivers is also found very much limited in the previous research, particularly in India. It is also understood from the previous study that there is no structured study which identified the most significant environmental ergonomic risk factors. More predominantly, in the previous studies, most of the researchers have used Nordic Questionnaire to capture the LBD prevalence using ‘Yes’ or ‘No’ type questions. This type of questions limits the use of advanced statistical tools for detailed analysis.

2.4 INFERENCE

The review of literature reveals that there are few research studies on occupational health hazards especially lower back disorder among vehicle drivers in India. The findings of the literature review confirm that there is an association between the vehicle operation and prevalence of LBD. Some of potential environmental ergonomic LBD risk factors for vehicle drivers are intensity of whole body vibration, Duration, Posture, work aspect (seat condition, road condition etc) psychosocial aspect etc. The findings of the literature survey confirm that there exists a relationship between LBD prevalence level, prevention of activities and medical intervention. The studies relating to potential environmental ergonomic risk factors LBD prevalence, prevention of activities and medical intervention are taken for discussion separately and given in next chapter.