2.1 EFFECT OF HIGH BODY MASS INDEX ON POSTURE:

2.1.1 Kingma and van Dieen (2008) did a comparative study of sitting posture on an office chair versus exercise ball to find out static and dynamic postural loadings during computer work on 10 female subjects and reported that sitting on an exercise ball resulted in 33% more trunk motion and 66% more variation in lumbar EMG. However, the fifth percentile and average lumber EMG were also higher when sitting on an exercise ball with 38% and 78% respectively. In addition, more spinal shrinkage occurred when sitting on an exercise ball than office chair. Arm flexion was reduced, but trapezius activation was unaffected when sitting on an exercise ball.

2.1.2 Beers et al. (2008) studied to determine the energy expenditure and performing clerical work in various postures on 24 men and women employed in sedentary clerical occupations. Energy expenditure was measured while word processing in three standardized postures; sitting in an office chair, a therapy ball, and standing. In conclusion, it has been suggested that, sitting on a therapy ball or standing rather than sitting in an office chair the passive energy expenditure increases while performing clerical work.

2.1.3 Watanabe et al. (2007) studied to examine the influence of trunk muscle co-contraction on spinal curvature during sitting for desk work with the help of EMG activity of the trunk muscles on 10 male volunteers and seen that co-contraction of the muscle during sitting while doing desk work could bring about the correct lumbar curvature, effectively stabilize the lumbo-pelvic region and decrease focal stress on the passive structure.

2.1.4 Gilleurard and Smith (2007) conducted a cross sectional comparative study on 10 subjects of obese and normal weight groups to find out the effect of obesity on trunk forward flexion motion in sitting, standing, postural adaptation and hip joint movement for a standing work task and concluded that decreased range of forward flexion, differing effects within the trunk, altered posture during a standing task and a concomitant increase
in hip joint movement give an insight into the etiology of functional decrement and musculoskeletal pain seen in obesity.

2.1.5 O'Sullivan et al. (2006) did a study to compare spinal-pelvic curvature and trunk muscle activation in two upright sitting postures (“thoracic” and “lumbo-pelvic”) and slump sitting in a pain free population with a method of spinal-pelvic curvature and surface electromyography of six trunk muscles were measured bilaterally in 2 subjects, (thoracic and lumbo-pelvic) sitting postures and slump sitting in 22 subjects. Thoracic compared to lumbo-pelvic upright sitting showed significantly greater thoracic extension. It has been concluded that, different upright sitting postures resulted in altered trunk muscle activation. Thoracic when compared to the lumbo-pelvic upright sitting involved less co-activation of local spinal muscles with greater co-activation of global muscles. These results highlight the importance of postural training specificity when the arm is to activate the lumbo-pelvis stabilizing muscles in subjects with low back pain.

2.1.6 Berrigan et al. (2006) examined the influence of obesity on speed and accuracy of upper limb goal directed movements in an upright standing position on eight healthy lean subjects (BMI between 20.9 to 25.0 kg/(m)$^2$) and nine healthy obese subjects (BMI 30.5 to 408.6 kg/(m)$^2$). Hand movement and velocity profiles were measured to quantify as well as the centre of pressure and segmental kinematics were analyzed to document postural stability. It has been reported from the study that obesity yields a decreased postural stability and imposes constraints on goal directed movements as well as obese individuals might be less efficient and more at risk of injuries than normal weight individuals in a large number of targeted work tasks and daily activities.

2.1.7 Bernard et al. (2003) studied to identify the influence of obesity on static postural control of teenagers with analysis of a stabilometric data of surface, lengths and spontaneous sway in the lateral (X) and antero-posterior (Y) axis with open eyes and closed eyes in Firm Floor and Foam Floor conditions and reported that, obesity significantly influences on the postural control as well as balance of the teenagers.
2.1.8 O’Sullivan et al. (2002) conducted a normative, single-group study to determine whether there is a difference in electromyography activation of specific lumbo-pelvic muscles with the adoption of common postures in a pain-free population. The study included 20 healthy adults, with equal representation of the genders. Surface electromyography was used to measure activity in the superficial lumbar multifidus, internal oblique, rectus abdominis, external oblique, and thoracic erector spinae muscles for four standardized standing and sitting postures. The findings showed that the lumbo-pelvic stabilizing musculature is active in maintaining optimally aligned, erect postures, and that these muscles are less active during the adoption of passive postures. The results of this study lend credence to the practice of postural retraining when facilitation of the lumbo-pelvic stabilizing musculature is indicated in the management of specific spinal pain conditions.

2.1.9 Ridola et al. (1994) studied postural changes in the lumbo-sacral segments of the spine due to severe obesity in 28 young adults to identify the correlation existing among Body Built Index (BBI), Lumbo-Sacral Angle (LSA) and Lordotic Angle (LA) and found that, no correlation between LSA and LA increasing BBI on the contrary a correlation was evident of decrease in LSA and LA took place after reduction of body weight with therapeutic intervention.

In this section, few studies have reported regarding an influence of obesity on various postural control, balance and functional decrement. The obese people are less efficient in a goal directed movements. Energy expenditure and trapezius muscle activation or load has been seen among clerical workers in sitting posture. Here the investigator believes that the postural defects due to muscular load during sitting clerical or computing task, which induces undue muscle activation and this defect will further deteriorate in case of obese individuals than that of normal weight categories. Few studies have been carried with smaller sampler size (10-24), which may not give correct information on postural defect and muscle activation in sedentary job.
Reliability and Validity of Tool:

2.1.10 Lynn and Nigel (1993) studied RULA (Rapid Upper Limb Assessment) a survey method developed for use in ergonomics investigation of work places where work related upper limb disorders are reported. This requires no special equipments in providing a quick assessment of the posture of the neck, trunk and upper limbs along with muscle function and the external loads experienced by the body and has proven its reliability and validity for use as a screening tool or incorporated into a wider ergonomics assessment of epidemiological, physical, mental, environmental and organizational factors.

2.1.11 Kerrie et al. (2006) did a study to find out reliability of a simple test protocol in the measurement of active rotation in standing. Inter-rater and intra-rater reliability was evaluated for a test measuring active rotation range in a standing position. Subjects stood with their feet comfortably apart while a horizontal bar rested on their shoulders. A plumb bob attached to the end of the bar was allowed to drop to the floor, indicating maximal rotation range achieved. Two raters measured 24 subjects (Mage =35 ±14 yr.), who were sedentary office workers and active recreational golfers, on two occasions separated by two weeks to obtain values for left and right trunk rotation range. The test had good intra-rater and inter-rater reliabilities, with standard error of measurement values varying from 5.6° to 8.6° against an overall mean range of 128°. This simple active rotation test requires inexpensive equipment and could be incorporated into clinical examinations when there is a need to assess active rotation in standing with minimal constraints.

The tools (RULA for sitting work posture and Plum Bob for standing posture) have been studied by above authors and found their reliability.

2.2 EFFECT OF HIGH BODY MASS INDEX ON FLEXIBILITY.

2.2.1 Aires et al. (2008) conducted a cross-sectional study to establish physical fitness levels in a school of 636 populations of 11-18 years old students and analyze differences according to body mass index status in overweight and concluded that, obese and overweight children have a low physical fitness level compare to normal peers.
2.2.2 Bovet et al. (2007) examined the relationship between physical fitness and obesity in 2203 boys and 2143 girls aged 12-15 years in the republic of Seychelles (Indian Ocean, African region) and found that a strong inverse relationship exists between fitness and excess body weight in adolescents.

2.2.3 Huang and Malina (2007) conducted a cross-sectional study to evaluate the relationship between BMI and a physical fitness index (PFI) based on four indicators of fitness (sit-ups completed in 60 s, standing long jump, sit and reach, and 800- or 1600-m run/walk) in a national sample of 102,765 Taiwanese youth 9-18 years of age and reported that, the physical fitness index (PFI) declines in a curvilinear manner with increasing BMI.

2.2.4 Brunet et al. (2007) conducted a cross-sectional study to evaluate the physical fitness and body composition of 1140 children (591 boys and 549 girls) involved in the “Quebec en Forme” (QEF) and to compare the data obtained to the reference values of 1981 Canada Fitness Survey (CFS) and found that, body mass index (BMI) and waist circumference (WC) were negatively correlated and that these association were more pronounced in older children.

2.2.5 Ara et al. (2007) conducted a cross-sectional study in a regional representative sample of 1068 children 7 to 12 years of age to determine the relationship between physical activity levels and adiposity and found out the level of physical activity had a significant effect on BMI, while maximum oxygen uptake (VO2 Max) was significantly related to adiposity. Among all physical fitness variables, VO2 Max showed the strongest relationship with BMI and fat mass.

2.2.6 Aya et al. (2007) did a study to examine the gender difference that exists in the relationship between percentage body fat and body mass index in Japanese children (187 boys and 163 girls aged 9-10 years, 137 boys and 155 girls aged 12-13 years) using a population based cohort and reported that correlation in boys were not as strong as those observed in girls.
2.2.7 Tokmakidis et al. (2006) conducted a cross sectional study to provide estimates for over weight and obesity in healthy school children (328 girls, 381 boys, mean age = 8.9+/-.1.6 years) and the relationship with health related fitness and concluded that there was high prevalence of childhood obesity in Greek school children and suggested that over weight and obesity are the limiting factors for fitness and performance.

2.2.8 de Greef et al. (2006) conducted a study to assess health related physical fitness of 5584 sedentary elderly in the Nederland with the help of Groninger Fitness Test (GFT) and reported that, lower physical fitness status has been seen among the age group of 55-65.

2.2.9 Betul et al. (2006) studied to examine the effects of Pilates exercise on the abdominal and lower back strength, abdominals muscular endurance and posterior trunk flexibility of 38 sedentary adults with the age group of 26-47 years and found that there was a positive effect of modern Pilates mat exercises on abdominal and lower back muscular strength, abdominal muscular endurance and posterior trunk flexibility in sedentary adults regardless of the fact that the body weight and fat percentage did not differ significantly.

2.2.10 Hancox et al. (2004) did a longitudinal birth cohort study on 1000 individuals up to the age limit of 26 years to find out association between child and adolescent television viewing and adult health in Dunedin, New Zealand and reported that television viewing in childhood and adolescent is associated with overweight, poor fitness, smoking and raised cholesterol level in adulthood. Excessive viewing might have long been lasting adverse effects on health.

2.2.11 Westerstahl et al. (2003) conducted a study to investigate changes over time and body dimensions and muscular and aerobic fitness in a representative of 855 samples of 16 years old girls and boys in secondary schools in Sweden from 1974 to 1995 with methods of height measurement along with run walk, two hand lift, sergeant jump, sit-ups and bench press and concluded that decreased aerobic fitness and increased static strength were associated with increased BMI.
2.2.12 Chen et al. (2002) studied the relationship between performance of health related physical fitness and BMI among the school children in Taiwan (444,652 boys and 433,555 girls within the age of 18 years) and concluded that the increased BMI was significantly related to decreased fitness.

In this section, the authors have given their view on the inverse correlation exists between obesity and physical fitness among school children below 18 years of age. Here the investigator believes that similar inverse correlation does exist among adult age groups in which the body flexibility is compromised, and this interferes in sustained activity, targeted job task and industrial productivity.

Reliability and Validity of Tool:
2.2.13 Tsang and Mak (2004) studied to establish the test-retest reliability of sit-and-reach test and to determine the capacity of sit-and-reach test to predict mobility of patients recovering from acute stroke and concluded that performance in sit-and-reach test was reliable and can significantly predict the mobility of patients with acute stroke at discharge.

The tool, sit-and-reach test is found to be reliable for measuring body flexibility in pathological conditions as claimed by the above author. The same tool has been used on normal or obese individuals for the measurement of lower back and hamstring flexibility.

2.3 EFFECT OF HIGH BODY MASS INDEX ON WORKRELATED MUSCULOSKELETAL DISCOMFORTS.

2.3.1 Shiri et al. (2008) studied to investigate the association between weight-related factors and the prevalence of Low back pain in 2575 young adults with the age group of 24-39 years in Finland and found that abdominal obesity may increase the risk of Low back pain.
2.3.2 Schulte et al. (2007) studied on work, obesity, occupational safety and health on 1.5 million workers and concluded that interrelationship exist between obesity and occupational asthma. In addition, obesity may modify the risk for vibration-induced injury and certain occupational musculoskeletal disorders.

2.3.3 Bhattacherjee et al. (2007) assessed the relationships of physical job tasks and living conditions with occupational injuries among coal miners. The sample included randomly selected 516 underground workers. They completed a standardized self-administered questionnaire. It has been reported that musculoskeletal disorders and certain personality traits were also significant in an univariate analysis. Therefore, heavy job tasks and poor living conditions strongly increase the injuries.

2.3.4 Sen and Richardson (2007) did a cross-sectional questionnaire study on 136 computer users in Malaysia on computer related upper limb discomfort and computer vision syndrome. They concluded that many computer users had higher RULA scores of the wrist and neck suggesting increased risk of developing occupational overuse syndrome.

2.3.5 Bernaards et al. (2007) conducted a study to investigate association among three modifiable risk factors (i.e. physical activity, cardio-respiratory fitness and BMI), work productivity and sickness absence among computer workers and concluded that in a population of white-collar workers with neck and upper limb symptoms, obese male workers showed significantly lower productivity than did lean or overweight workers.

2.3.6 Berrigan et al. (2006) examined the influence of obesity on speed and accuracy of upper limb goal directed movements in an upright standing position on 8 healthy lean subjects (BMI between 20.9 to 25.0 kg/(m)$^2$ and nine healthy obese subjects (BMI 30.5 to 408.6 kg/(m)$^3$). Hand movement and velocity profiles were measured to quantify as well as centre of pressure and segmental kinematics were analyzed to document postural stability. It has been reported from the study that obesity imposes constraints on goal directed movements as well as obese individuals might be less efficient and more at risk of injuries than normal weight individuals in a large number of work tasks and daily activities.
2.3.7 IJmker et al. (2006) did a study to quantify the contribution of exposure to occupational computer use to an incidence of hand, arm, shoulder and neck symptoms with the help of prospective research on musculoskeletal disorders in 1821 office workers (PROMO) and reported that, the advantage of PROMO study includes the long follow-up, the repeated measurement of both exposure and outcome and the duration of computer use.

2.3.8 Peltonen et al. (2003) compared the work restricting musculoskeletal pain in an obese and general population and investigated changes in the incidence of and recovery from musculoskeletal pain after bariatric surgery or conventional obesity treatment on 6328 Swedish obese subjects and concluded that they have more problems with work restricted musculoskeletal pain than general population.

2.3.9 Devereux et al. (2002) conducted a study on 891 computer operators and technicians out of 1514 office workers to investigate the potential interaction between physical and psychosocial risk factors at the workplace that may be associated with symptoms of musculoskeletal disorders of neck and upper limb. They found out workers highly exposed to both physical and psychological workplace risk factors were more likely to report symptoms of musculoskeletal disorders than workers highly exposed to one or other. There was a definite interaction between physical and psychosocial risk factors in the workplace that increased the risk of reporting symptoms of upper limbs.

2.3.10 Han et al (1997) examined the association of Low Back Pain with waist circumference, height, and waist to hip ratio and BMI on 5887 men and 7018 women in Netherlands and concluded that, women who were overweight or with a large waist are more prone to low back pain.

2.3.11 Molteni et al. (1996) studied the epidemiology of musculoskeletal disorders caused by biomechanical overload and reported that specific types of work-related exposure are associated with development of musculoskeletal pathologies, and that the relative risks for certain types of occupational exposure can be extremely high. This has been proven in
relation to tendonitis of the shoulder and hand-wrist, carpal tunnel syndrome and tense neck syndrome as well as several localized specific musculoskeletal symptoms, such as pain joint stiffness.

In this section, many studies already have reported on the association of obesity with increased musculoskeletal disorders, some reports on regarding the obese women and excess biomechanical load on body tissues to increase muscular discomforts and few studies also shown only one or few body part disorders associated with obesity. Whereas, in the current study almost all body parts are considered, and the investigator believes that overweight and obesity has definite influence on increased work related musculoskeletal discomforts and thereby work absenteeism increases to interfere in productivity.

Reliability and Validity of Tool:

2.3.12 Hedge et al. (1999) conducted a study on effects of keyboard tray geometry on upper body posture and comfort with the use of CMDQ (Cornell University Musculoskeletal Discomfort Questionnaire) and found that reaction to using a conventional keyboard on a downward tilt system were positive, i.e. 80% of typing wrist movements put the hand into a neutral zone with the downward arrangement.

2.3.13 Oguzhan et al. (2008) did a study on cross-cultural validity and reliability of Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) in Turkish language and found that it was a highly reliable and valid tool and could be used effectively.

The reliability and validity of CMDQ have been claimed by above researchers in different countries and the similar report has been found in Indian industries.
2.4 EFFECT OF HIGH BODY MASS INDEX ON PSYCHOSOCIAL STRESS.

2.4.1 Amy et al. (2008) conducted a study on 882 subjects with an age range of 18 to 82 years to identify the influence of stress and emotion on eating habits and found out these factors have got strong association with overweight and obese individuals.

2.4.2 Wirtz et al. (2008) conducted a study on 42 men with age group of 21-65 years and BMI of 21-34 kg/m$^2$ to find out the association of the higher BMI with reduced glucocorticoid inhibition of inflammatory cytokine production following stress while controlling age and blood pressure measuring glucocorticoid inhibition of LipoPolySaccharide (LPS) - stimulated release of the pro-inflammatory cytokine Tumor Necrosis Factor (TNF)-alpha and reported that with increasing BMI, glucocorticoids are less able to inhibit TNF-alpha production following stress.

2.4.3 Torres and Nowson (2007) examined the relationship between stress, eating behavior, and obesity on 13 female subjects and found that stress-induced eating may be one factor contributing to the development of obesity.

2.4.4 Ostry et al. (2006) conducted a cross-sectional population-based study on 1101 subjects (526 men and 575 women) to examine the relationship between psychosocial and working conditions and BMI in working people. These finding suggested that among men and women, there were different pattern of exposures to psychosocial working conditions and association with BMI. Among men working long hours was associated with higher BMI, and this association was partly independent of job stress.

2.4.5 Nishitani and Sakakibara (2006) examined the relationship between obesity, job stress and eating behavior in male Japanese workers. They tested 208 male workers aged 19 to 60 years and found that obese workers tend to be in a stressful state from high job demand and low job latitude in the workplace and such stressful condition stimulates eating behavior that eventually contributes to obesity.
2.4.6 Steptoe et al. (1999) assessed the influence of abdominal obesity and chronic work stress on ambulatory blood pressure in men and women with 156 samples. They concluded that abdominal obesity in men is characterized by a tendency towards heightened stress-induced physiological activation, but the tendency will only be manifested in the presence of appropriate environmental challenges such as chronic work stress.

2.4.7 Vincent et al. (1999) carried out a comparative and descriptive study to determine whether BMI predisposes the myocardium to the oxidative stress as evidenced by higher tissue level of myocardial lipid peroxidation on 12 month old 13 male fatty Zucker rats measuring their Basal lipid peroxidation, oxidative and antioxidant enzyme activities following an iron-mediated challenge in vitro. The result indicated that obesity predisposes the myocardium to oxidative stress and is associated with elevated myocardial enzyme activities.

In contrast:

2.4.8 Kouvonen et al. (2005) studied the association between the work stress and BMI with the help of cross-sectional questionnaire data obtained from 45,810 employees participating in the Finish Public Sector Cohort Study and found the results with aggravated scores showed that lower job control, higher job strain and higher effort-reward imbalance were associated with a higher BMI, but the relationship was weaker than those obtained with the aggravated score.

2.4.9 Chandraiah et al. (2003) did a study to find out the effect of age on occupational stress and job satisfaction with a sample size of 105 industrial managers working in different large scale industries. The Occupational Stress Index (OSI) developed by Srivastava and Singh (1983) and Job Descriptive Index (JDI) by Smith Kendal (1963) were used to assess the level of job stress and job satisfaction respectively. They reported that subjects of lower age group (25-35 years) had a maximum level of stress than their counterparts of middle age (36-45 years) and old age (46-55 years), and the age found to be negatively correlated with occupational stress and positively with job satisfaction.
In this section, many studies described on stress, obesity and eating behavior, which is related to each other. Few studies were shown with smaller sample size, which may not have much consistency. In contrast, some authors reported on weaker association of obesity with aggravated scores of job strain as well as an inverse relationship between age and occupational stress. Furthermore, animal study shows the influence of obesity on oxidative stress on myocardial muscles and associated with myocardial enzyme activities.

Reliability and Validity of Tool:

2.4.10 Rajan and Nag (1995) assessed the Occupational Stress Index by Srivastava and Singh on employees in the production department of an organized industry and found that, the OSI tool was valuable in quantification of stress.

The OSI has high reliability and validity in Indian industries as claimed by above authors. Hence, this tool has been used in Indian computer industries with a strong belief and expectation of a positive result.

2.5 RELATIONSHIP OF POSTURE AND WORK REALTED MUSCULOSKELETAL DISCOMFORTS.

2.5.1 Straker et al. (2008) did a cross-sectional study on to examine the relationship between prolonged Neck/shoulder pain (NSP) and habitual sitting posture on 1593, 14 year adolescents using the sagittal plane digital photograph. In their study females were reported with a higher prevalence rate than males.

2.5.2 Fung et al. (2007) did a case control study on 166 cases and 111 controls to identify high risk wrist postures and actions, which may occur across various occupations and confirm that frequent flexion, extension and sustained force of the wrist increase the risk of developing carpal tunnel syndrome.
2.5.3 Marcus et al. (2002) undertook a study to evaluate an association between posture and musculoskeletal disorders of neck, shoulder, arm and hand. They suggested that musculoskeletal disorders can be reduced by encouraging specific seated posture.

2.5.4 Pascarelli and Hsu (2001) examined four hundred eighty five patients whose chief complaints were work related pain and other symptoms received a comprehensive upper-body clinical evaluation to determine the extent of their illness. The group had a mean age of 38.5 years. Sixty-three percent of patients were females. Seventy percent was computer users. 28% were musicians, and 2% were engaged in a repetitive work. The time between the onset of the symptoms and initial visit ranged from two weeks to over 17 years. A majority sought care within 30 months with the greatest number of them seeking care before 12 months. Fifty nine percent of subjects were still working despite increasing pain and symptoms such as weakness, numbness, tingling, and stiffness. It has been concluded that despite an initial presentation distally. Work-related upper-extremity disorders are a diffuse neuromuscular illness with significant proximal upper-body findings that affect the distal function. While neurogenic Thoracic Outlet Syndrome remains a controversial diagnosis, the substantial number of patients with positive clinical findings in this study lends weight to the concept that posture related neurogenic Thoracic Outlet Syndrome.

In this section, studies show a postural influence on musculoskeletal disorders with some neurological complaints and some study reports on especially neck pain, which is more involved in females than their male counterparts.

2.6 RELATIONSHIP OF STRESS WITH WORK REALTED MUSCULOSKELETAL DISCOMFORTS.

2.6.1 Schell et al. (2008) conducted a study to identify the association between stress biomarkers and neck, shoulder and back pain in healthy media workers and found that the individuals in working life with a high level regenerative/anabolic activity has less pain than others.
2.6.2 Hannan et al. (2005) conducted a study to identify the association between the psychological stress “job strain” and incident neck-shoulder and arm-hand musculoskeletal symptoms with the help of the job strain questionnaire and concluded that workers who reported high job strain were more likely to develop neck-shoulder symptoms.

2.6.3 Punnett et al. (2004) conducted a longitudinal cross-sectional study to estimate cumulative incidence and persistence of upper extremity soft tissue disorders in a fixed cohort of automotive manufacturing workers and to quantify their association with ergonomic exposures with the help of Questionnaire and standardized physical examination and reported that association of musculoskeletal disorders were with exposure to combine ergonomic stressors.

In this section, authors have reported regarding an influence of job stress on musculoskeletal disorders mostly neck shoulder symptoms. Some authors also reported on ergonomic stressors, which may be a sudden change from the conventional workstation in first instance.