Abstract

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(Under the direction of Dr. Mirka)

Individual factors are becoming increasingly more prevalent in studies that explore occupational musculoskeletal injury/illness. Empirical and theoretical evidence supports further research into the role of individual differences in psychosocial attributes in the occupational exposure, especially the injury outcome process and potential mechanisms that may be at work. The goal of the current work was to understand whether certain individuals may place themselves at risk by taking infrequent breaks (i.e. working through pain or fatigue) if they are given the freedom to decide the work pace and work-rest schedule. The hypothesis is that individuals with certain personality characteristics like type A maybe at higher risk due to their choice of less frequent breaks and a fast paced approach to work just to get the job done as compared to type B personality. This hypothesis is based on the inherent time-urgency characteristic of type A individuals.

Sixteen subjects (8 of each personality type) were asked to perform a 40 cycle overhead assembly work involving running nuts onto bolts located on an overhead board. The whole 40 cycle session was self paced and subjects had the freedom to take as many breaks as they wanted and these breaks could be as long as they wanted. The results showed that there was no significant effect of personality type on the task performance variables- total cycle time, total break time, average break time, average cycle time, # of breaks, average pain scale and average pain scale at breaks. These

results were not consistent with the theory which supported the fast working of type As based on their time-urgency characteristic. Although no previous studies have looked at an overhead assembly task, the results of this study were consistent with other recent studies in our laboratory showing no performance effects of personality type on simple, unchallenging tasks.

Effect of personality type on performance of an overhead task

By

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Dedication

I had never imagined myself graduating with a master's degree from the United States of America when I started my academic pursuit. But today when I look back at all those years of effort and determination, I see that the values and the confidence induced in me by my family, especially my parents, was very influential in where I have reached today. I have realized slowly but surely, especially during the past two years that one really needs the support and love of one's family to sail through these trying times. For all that my parents have gone through for my education and their relentless support for me to pursue higher studies; I hereby dedicate my thesis work to my parents- Sudhakaran and Chandramathy. I hope that by earning a masters degree in an area that always interested me but could not pursue in India, I have reached my educational potential and in a way fulfilled all my parent's dreams and aspirations. I am sure that this dedication in no way reflects the true appreciation and love I have for my parents for all that they have done for me. I hope that I have made them proud by just being the person I am today.

Biography

Sunil Sudhakaran is the second of the two sons to Sudhakaran and Chandramathy. His parents moved to Mumbai, India in the late 1960s from the small southern beautiful Indian state of Kerela. They now live in Mumbai with their first son Sudhir and his family. After completing his four year diploma in Production engineering, Sunil got admitted to one of the finest engineering institution in Mumbai, Veermata Jijabai Technological Institute (V.J.T.I.). After earning his bachelor degree in Production engineering from V.J.T.I in 1999, he worked for one year for a tractor manufacturing company, primarily doing materials management and vendor development. He then worked for a small valve manufacturing company as a product engineer, designing plastic parts and injection molding dies. He decided to pursue his masters in Industrial Engineering from North Carolina State University with specialization in physical ergonomics which seemed to be his area of interest. While working towards his masters starting fall 2001, he had the privilege to work with Dr. Sommerich for 2 semesters on the computer usage study she was involved with. During the summer of 2002, he gained great insights in the practical application of physical ergonomics while working for BMW manufacturing Corp. at Spartanburg, South Carolina. The following 2 semesters he was honored to work with Dr. Mirka at NCSU ergo laboratory working on intervention study in the Furniture industry.

Acknowledgements

One of the things you realize while working on your thesis is that it is almost impossible to do it unless you are really motivated and interested. You also need the right guidance and help to find the topic you find most interesting. I found that without my advisor and my role model - Dr. Gary Mirka, I could have never completed this thesis. I would really like to thank him from the bottom of my heart for all the optimism and patience he has shown during this whole time. He has shown immense confidence in my ideas (which have even surprised me occasionally) and I have also learned a lot more than just ergonomics theories from him. I would also like to thanks the other committee members, Dr. Nelson Couch and Dr. Hester Lipscomb for their support and help. I would like to thank my friend and senior colleague Naomi Glasscock who has shared important findings from her study. I would also like to thank my fellow students and friends, Karen Noack, David Brandenburg, and Gwansoeb Shin for their friendship and support. Finally I would like to thank my family especially my parents, my brother Sudhir and my sister-in-law Jeena for their never ending support and for believing in me even when I questioned my abilities.

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1.0 Introduction to ergonomics

Although the science and practice of ergonomics go back to the early 1900s, it is only in its seventh decade of identifiable professional existence. Professional ergonomists now work on a wide variety of systems, ranging from simple hand tools to highly complex equipment, software and interfaces. Professor Brian Shackel, the International Ergonomics Association (IEA) historian, has followed the focus of ergonomics from the 1950s to the 1990s and how it has shifted from military ergonomics (in early 1950s) to computer and cognitive ergonomics (in late 1990s), and their application to industrial systems (Hendrick, 1993). Derived from the Greek ergon (work) and nomos (laws) to denote the science of work, ergonomics is a study of human-machine systems and is now applied to almost all aspects of human behavior.

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system. It is the profession that applies human knowledge collected through research to design complex systems so as to ensure human well being and optimize overall system performance.

Ergonomics is a science concerned with developing knowledge about human behavior, their limitations, and other characteristics which helps to design system interfaces. As a practice, ergonomics applies this knowledge of human-system interface technology to analyze the design and evaluate safety, health and quality of life in general. Within the discipline, there are various domains of specialization which represent different areas, namely physical, cognitive and organizational ergonomics.

Cognitive ergonomics deals more with mental processes, such as perception, memory, reasoning, and motor response, and how they affect interactions among humans and other components of a system. The areas within cognitive ergonomics include mental workload, decision-making, skilled performance, human-computer interaction, and training. Organizational ergonomics deals with the optimization of sociotechnical systems, including their organizational structures, policies, and processes. The topics covered under this area include work design, design of working times, teamwork, participatory design, community ergonomics, cooperative work, organizational culture, telework, and quality management. Physical ergonomics deals more with human anatomical, anthropometric, physiological and biomechanical characteristics and how these interact with each other to represent physical activity. The areas within physical ergonomics which are studied include working postures, materials handling, repetitive movements, work-related musculoskeletal disorders, workplace layout, safety and health. The prevention of work related illness/injury is a primary focus in this discipline and issues related to this topic form the foundation of the current study which is covered in more detail in the subsequent section.

1.1 Musculoskeletal Disorders

The U. S. Department of Labor defines a musculoskeletal disorder (MSD) as an injury or disorder of the muscles, nerves, tendons, joints, cartilage, and spinal discs and typically does not include injuries or disorders caused by slips, trips, falls, or similar accidents. The two basic types of injuries are acute injuries and chronic injuries. Acute injuries are usually the result of a single, traumatic event (macrotrauma). Acute injury usually occurs due to the result of a single load exceeding the tolerance of a tissue or a body part. Common examples include wrist fractures, ankle sprains, shoulder dislocations, and muscle strains. Chronic injuries on the other hand are more subtle and usually occur over time. They are the result of repetitive microtrauma to the tendons, bones and joints. Cumulative Trauma Disorders (CTDs) are chronic injuries, which occur due to repetitive, submaximal loads on a tissue or body part over a prolonged period of time. CTD is a collective term for disorders characterized by discomfort, impairment, disability or persistent pain of soft tissues. It can be caused or aggravated by repetitive motions including vibrations, static and/or awkward postures, and forceful movements at work. Common examples of CTDs include tennis elbow (lateral epicondylitis), carpal tunnel syndrome and swimmer's shoulder (rotator cuff tendinitis and impingement).

1.1.1 Back disorders

Back pain is one of the most common and significant musculoskeletal problems in the work place today. The Occupational Safety and Health

Administration in their 1999 annual report reported that over 1 million workers are affected by lower back pain. Back pain was also ranked second as the leading cause of days away from work. According to the same report, low back disorders in the United States costs more than $100 billion each year. An average claim of low back injury costs $8,300, which is almost twice the average cost of all other types of claims combined together.

The National Institute of Occupational Safety and Health (NIOSH) in 1998 summarized over 40 recent studies related to low-back musculoskeletal injuries to find the various work related risk factors that contribute to lower back disorders. According to the NIOSH report, the most significant risk factors associated with lower-back injuries were job activities that required heavy lifting, and jobs that exposed workers to whole body vibration. Awkward postures and heavy physical work were also identified as risk factors in the report.

1.1.2 Upper extremity disorders (Hand, wrist and shoulder)

Work related MSDs for the upper extremity have been found to be right behind lower back injuries for the number of lost days in the US according to OSHA's annual report in 1999. The disorders typically involved are hand, wrist and elbow problems are non-specific hand and wrist pain followed by tendinitis, ganglion cysts, and carpal tunnel syndrome. Research has found forcefulness, adverse posture, repetition or continuous activity and duration of exposure as the major risk factors associated with the upper extremity disorders. Since the main focus of this study is related to the shoulder joint, a detailed description of anatomy, biomechanics, types of shoulder disorders and their associated risk factors will be presented in subsequent sections.

1.2 Epidemiology for MSD

1.2.1 Incident rates

In the report by Department of Labor Bureau of Labor Statistics in 2000, over 577,800 musculoskeletal disorders cases were reported involving days away from work. The report also states that although both total injuries and illnesses with days away from work and MSDs have decreased since 1992, MSDs continue to account for more than one in three of the total lost work time cases (Lost-work time injuries and illnesses: characteristics and resulting time away from work, 2000, United States Department of Labor Bureau of Labor Statistics)

1.2.2 Cost to the industry

Costs for work-related musculoskeletal disorders are difficult to estimate due to various factors involved. Webster and Snook (1994) analyzed 1989 insurance claims data from 45 states, looking only at upper extremity disorders and specifically as cumulative trauma disorders. They estimated that the total compensable cost for upper extremity disorders in the U.S. was $563 million in 1989. The National Institute of Occupational Safety and Health (NIOSH) has estimated that the annual worker's compensation costs for neck and upper extremity disorders are over $2 billion, plus $90 million in direct costs (NIOSH, 1996). In a study in Australia estimating the cost associated with specific musculoskeletal disorders, MSDs we reported to be the third leading cause of health system expenditures, with an estimated total expenditure of $3,002 million in 1993–94. In similar study in Britain looking at workplace accidents and work-related ill health (1996), the costs associated with musculoskeletal disorders affecting the lower back were between £315 million and £335 million.

1.2.3 Epidemiology for shoulder MSDs

Upper extremity musculoskeletal injuries or disorders pose a significant concern to today's industry, both in terms of cost and suffering. The information or knowledge of risk factors for shoulder disorders is based on epidemiological studies in the field and experimental studies in the laboratory. Epidemiological studies have typically investigated the associations between physical factors such as load, duration etc and clinically defined shoulder disorders such as shoulder tendinitis. Herberts et al. (1984) in their study of employees at a shipping company found that the welders, primarily doing manual labor, had a prevalence of 18.3% for supraspinatus tendonitis as compared to 2% for clerks doing office work. Grocery store checkers (15%) were reported to have a higher prevalence of rotator cuff tendinitis than non checkers (4%) in the health hazard evaluation report by Baron et al. (1990). Prevalence of humeral tendinitis was found to be 9.2% among assembly line packers as compared to 3.8% among shop assistants in a cross-sectional study by Luopajarvi et al. (1979). Wells et al. (1983) in their cross sectional study found a significant prevalence of shoulder problems among letter carriers with increase in weight carried. A one year follow up study in a forest industry company, found that physically heavy work load and mental overload were associated with severe shoulder pain.

Apart from these epidemiological studies, only rarely have we seen direct measurements been used to estimate exposure or outcome. This implies that the information we have so far on physical load factors are crude and may even have bias (because of its subjective nature). The severity of upper extremity disorders is influenced not only by biomechanical factors, but also by other work organizational factors, the worker's perception of the work environment, and individual factors (Bradley & Rempel, 1996). The etiology of the cumulative trauma disorders is complex and may include various factors from the occupational work, workplace, and worker as well as non-occupational factors. Occupational tasks that require high force, high repetition and awkward postures increase the chances of getting injured, especially if these tasks are not complimented by appropriate rest breaks.

1.3 The shoulder

1.3.1 Anatomy of the shoulder

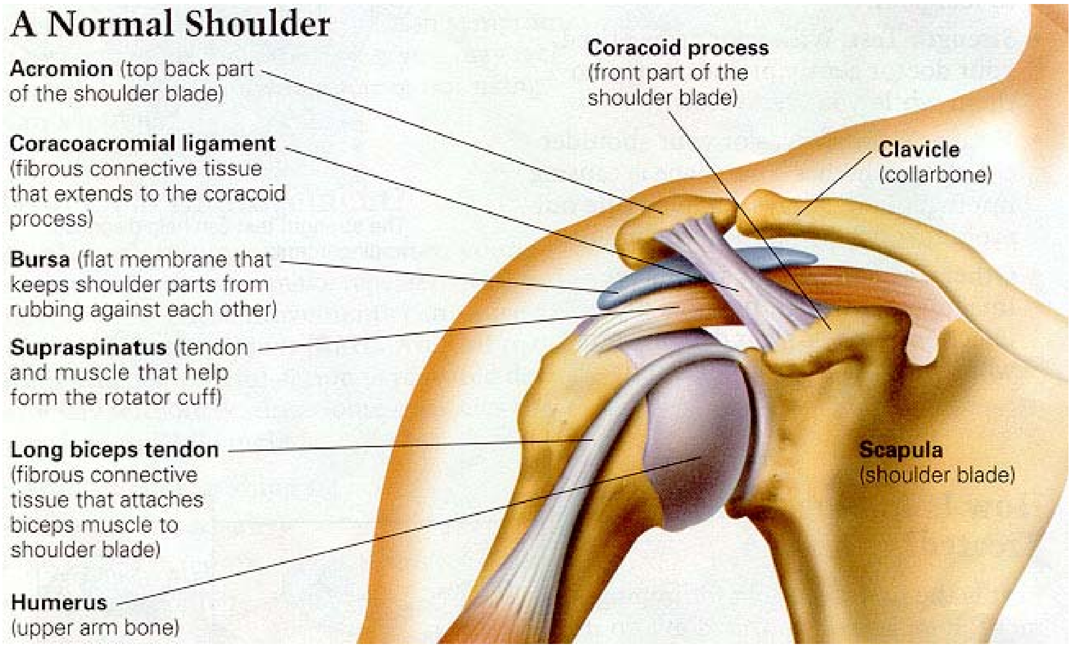


Figure 1 Shoulder anatomy

Adapted with permission from http://www.ortho-md.com

The shoulder is a complex system of bones, muscles, tendons, and ligament that attach the upper extremity to the torso. The primary function of the shoulder is to direct and support the hand activities.

1.3.1.1 Bones

The three bones involved in the shoulder are the scapula, the humerus, and the clavicle. The clavicle is attached to the acromion in the upper lateral aspect of the shoulder, and the other end attaches to the sternum. The scapula covers part of the dorsal aspect of the rib cage. The three major joints which constitute the shoulder joint are the glenohumeral joint (scapulohumeral joint), the sternoclavicular joint and the acromioclavicular joint. Each of the above joints can act individually but total shoulder movement is the sum of the movement of the movement contributed by all the above joints (Inman & Lucas, 1957).

The sternoclavicular joint: It is the joint where the clavicle articulates with respect to the manubrium of sternum. The sternoclavicular joint displays three degrees of freedom whose movement axes are in the sagittal plane and frontal planes as well as along the bone axis of the clavicle. The elevation of the clavicle is limited by the lower portion of the sternoclavicular joint and the costoclavicular ligament (Inman & Lucas, 1957, Kent, 1971).

The acromioclavicular joint: This is an articulation between the acromial end of the clavicle and the acromion of the scapula and surrounded by a fibrous capsule. The joint receives its stability and integrity from various ligaments rather than mating surfaces of the bones. Although not well defined, the acromioclavicular joint can have three degrees of freedom motion and types of movements are usually defined with respect to the scapula (Inman & Lucas, 1957, Kent, 1971).

The Glenohumeral joint: This is a ball and socket joint between the glenoid fossa of the scapula and the head of the humerus. The contact area between the two articulating surfaces is small because the glenoid cavity has a much smaller surface area as compared to the humerus head. A joint capsule consisting mainly of the glenohumeral ligaments provides a loose sleeve around the joint. It is at this joint that the primary motion of the arm is facilitated (Inman & Lucas, 1957, Kent, 1971).

1.3.1.2 Muscles

The stability and mobility of the shoulder are maintained by three major groups of muscles as listed below (Ali, 1979):

- The scapulohumeral group (those passing from the scapula to the humerus) which consist of the supraspinatus, infraspinatus, teres minor, subscapularis, deltoid and teres major.
- The axioscapular group (those passing from the torso to the scapula) which consist of the trapezius, rhomboids, serratus anterior, and levator scapulae.
- The axiohumeral group (those passing from the torso to the humerus) consist of pectoralis major, pectoralis minor and lattissimus dorsi.

The muscles acting on the humerus to elevate the arm are the biceps brachii, the supraspinatus, the deltoid and the short rotator cuff consisting of the infraspinatus, the teres minor and the subscapularis (Inman & Lucas, 1957, Peat, 1986).

<u>Biceps brachii</u>: this is the least important of the elevator groups and acts as an abductor only under certain conditions. In its normal position it can exert practically no effective force to abduct the arm. However if the humerus is externally rotated 90 degrees, then it can act as a pulley mechanism to abduct the arm (Inman & Lucas, 1957).

<u>The supraspinatus</u>: this muscle is similar in its pulley mechanism as is the biceps. It originates above the spine of the scapula with its tendinous insertion on the greater tuberosity of the humerus. Electromyographic studies of the supraspinatus muscle

during abduction have shown that it contracts progressively throughout the entire phase of abduction with maximal activity at 100 degrees of abduction (Inman & Lucas, 1957).

The deltoid and the rotator cuff: The deltoid and its association with the rotator cuff is the most important mechanism for arm abduction. The direction of the deltoid's pull on the humerus is upward and outward. The contraction of the deltoid does not cause the arm to swing out into abduction but only results in the humeral head being forced against the acromion. If the action of the deltoid is combined with the short rotator muscles (subscapularis, infraspinatus and teres minor), abduction is easily accomplished. The rotation is produced through the forces acting in two opposite directions. The upward and downward pulls of the deltoid and the short rotators, respectively, cancel out each other and allow for free rotation when the two sets of muscles act through the force couple mechanism. Both these muscle groups have been found to be acting continuously throughout the motion of abduction. They reach maximal activity between 120 and 140 degrees of abduction (Inman & Lucas, 1957).

The second group of muscles necessary for elevation of the arm are those that act on the scapula to produce the 60 degrees of outward motion of the scapula needed to complete the full range of humeral abduction. Outward rotation of the scapula is accomplished by two muscles: the trapezius and the serratus anterior. Because the scapula is fixed to the clavicle at the anterior edge of the acromion, the scapula must rotate around this point. The upper trapezius acting on the acromion rotates the scapula outward, while the lower trapezius pulls downward on the lower scapular spine, continuing the rotation. Finally the serratus anterior, by pulling forward on the scapula, gives additional force for the movement (Kent, 1971).

1.3.1.3 Nerves and blood vessels:

The nerves and blood vessels that run into the arm and hand start at the side of the neck. They exit from the side of the spine through small openings between each vertebra called foramen. As they leave the spine, the nerves are referred to as nerve roots. The individual spinal nerve roots then begin to join together to form the nerves that will run into the arm and hand. The nerves travel between two muscles in the neck (the scalene muscles), over the top of the rib cage, under the collar bone (clavicle), through the armpit (axilla) and down the arm to the hand.

The subclavian blood vessels have a similar route from the torso to the hand through the shoulder.

The nerves and vessels come together in the shoulder region to form a neurovascular bundle. This neurovascular bundle consists of the nerves (brachial plexus) and blood vessels (subclavian vessels) which pass from the cervical area towards the armpit.

1.3.2 Biomechanics of the shoulder

The elevation of the arm consist primarily of two phases – first the movement of the humerus on the scapula, then scapula on the chest wall, and later the humerus on the scapula again (Dvir & Berme, 1978). All of these above said motions occur almost simultaneously and this synchronous motion of the scapula and humeral components of shoulder is called the scapulohumeral rhythm. Kent (1971) state that the scapulohumeral rhythm proceeds as follows: After an original period of stabilization, each 15 degrees of abduction of the arm consists of 10 degrees of abduction at the glenohumeral joint and 5 degrees outward rotation of the scapula. These movements occur simultaneously producing a smooth rhythmic motion. Thus in 180 degrees elevation of the arm, 120 degrees occur at the glenohumeral joint, and 60 degrees through outward rotation of the scapula. The total of 60 degrees of scapular rotation is achieved through 30 degrees elevation of the clavicle at the sternoclavicular joint and remaining 30 degrees at the acromioclavicular joint. Axial rotation of 50 degrees of the clavicle along its axis is an important factor in this mechanism.

1.3.3 Shoulder disorders

1.3.3.1 Thoracic outlet syndrome (TOS)

Thoracic outlet syndrome (TOS) is a disorder that affects the nerves in the brachial plexus (nerves that pass into the arms from the neck) and various nerves and blood vessels between the neck muscles and axilla (armpit). In the thoracic outlet syndrome, the nerves and vessels of the neurovascular bundle are compressed at the thoracic outlet area. Symptoms of TOS include pain, weakness, numbness and tingling, swelling, fatigue or coldness in the arm and hand, and weak pulse at the wrist. Elevated arm postures, work requiring pulling the shoulders down (carrying load on shoulder) and poor postures are some of the risk factors associated with TOS. Sommerich et al. (1993) stated that while working with an overhead posture, the pectoralis minor muscle or the scalene muscles of the neck may pinch the nerves and blood vessels which are beneath these muscles.

1.3.3.2 Occupational muscle pain

Hagberg (1987) defines occupational muscle pain or tension neck or myofascial syndrome as the pain in the shoulder area with tenderness to the lower part of the trapezius muscle. There may a variety of possible mechanism leading to occupational muscle pain such as mechanical trauma, fatigue, metabolic alterations and myofascial pain (Edwards, 1988). Edwards (1988) suggested in his study of the pathology of occupational muscle pain that pain during work may be associated with impaired muscle energy metabolism or fatigue. This impaired muscle energy metabolism or fatigue may be due to the lack of blood flow to the shoulder and neck region. Research has shown that the intramuscular pressure shows a linear increase with increasing abduction or flexion angle (Sigholm et al., 1984). In the supraspinatus region, a flexion or abduction angle of more than 30 degrees is enough to raise the intramuscular pressure above the level where muscle blood flow is impeded (Viikari-Juntura, 1996). This impairment of the blood flow may produce local ischemia and cause occupational muscle pain.

1.3.3.3 Shoulder impingement syndrome

Shoulder impingement syndrome is caused by compression of the tendons of the rotator cuff between the acromion process (a part of the shoulder blade) and the head of the humerus. As the humerus is rotated while elevating the arm, it tends to pinch the tendons of the rotator cuff between the humerus head and the acromion. This could lead to tearing the rotator cuff tendons and pain. Some of the common risk factors for shoulder impingement syndrome are prolonged work at or above shoulder level, static positions or postures especially prolonged abduction of the arm.

1.4 Physical risk factors

Based on epidemiological and experimental evidence, the following work-related physical risk factors for shoulder disorders have been identified:

1. Heavy physical work: Many studies have shown an association between heavy physical work and shoulder injury/pain. One study by Stenlund et al. (1992), which investigated workers with exposure to heavy physical work from 10 to 28 years observed an increase risk due to cumulative exposure to manual work. Heavy physical work generally involves manual handling of heavy loads, non-neutral trunk postures, and elevated postures of the arm.
2. Manual handling: Manual handling activities generate high loads on all shoulder structures. Many studies which looked at the rotator cuff muscles and the deltoid have found a increase risk of cumulative trauma due to manual handling.

3. Elevated postures of arm: According to Eira Viikari-Juntura (1992), there is some epidemiological evidence that supports the association between elevated arm postures and shoulder pain (Bjelle et al., 1979; Sakakibara et al., 1995) as well as supraspinatus tendinitis (Herberts et al., 1981). The occupations investigated in these studies were orchard farmers and shipyard welders. Other studies have shown that the activity of the shoulder muscles increases with increasing elevation of the arm (Sigholm et al., 1984). A flexion angle of $\geq 30^{\circ}$ without any hand load increases the intramuscular pressure level to the extent of blood circulation disturbances (Sigholm et al. 1984). After long hours of extensive shoulder exercise the neuromuscular recovery may be incomplete for hours (Mathiassen, 1993). Elevate arm postures may also be associated with mechanical irritation of the rotator cuff tendons.

   The results from one study done on welders showed that suspending the arm may reduce the shoulder muscle load but the intramuscular pressure of the supraspinatus remains at a level where the blood flow to the shoulder muscles is still compromised (Jarvholm et al., 1991).

4. Non-neutral trunk postures: Viikari-Juntura (1992) states that Schuldt et al. (1987) investigated the myoelectrical activity of the neck and shoulder muscles in different postures doing simulated soldering work in the laboratory. They found that sitting with the spine slightly tilted backward and the cervical spine vertical was associated with the least myoelectrical activity. The posture with

the whole spine flexed was associated with the highest activity. These findings suggest that non-neutral trunk postures may influence the shoulder muscles and their risk in more than one way.

5. Static postures: This is defined as tasks which require workers to sustain positions for long periods of time. One field study done by Herberts et al. (1984) on shipyard welders with an earlier onset of supraspinatus tendinitis, and comparing with plate workers in the same company found that the prevalence of supraspinatus tendinitis was similar in the two groups. The average age for welders was 6 years less than that of the plate workers. While both the jobs were classified and rated in high physical workload by the workers, welding was described as more of a static job as compared to plate workers who had a more dynamic task.

   Another study by Burt et al. (1990) looked at upper extremity CTDs at a major newspaper company. They found an 11% prevalence of shoulder symptoms in their study. These symptoms were associated with the percentage of time spent typing at computer terminals which means static postures for extended periods of time.

6. Repetitive work: This had been one of the prime risk factor for MSDs of the upper extremities. Sommerich et al. (1993) state that Hagberg and Wegman (1987) who summarized the results of various epidemiological studies on exposure factors related to thoracic outlet syndrome (TOS) and other shoulder

disorders found the odds ratio to be 4.0 for having exposed to repetitive arm movements. Cash register operators and assembly line workers and packers were classified as being exposed to highly repetitive arm movements.

An experimental study done by Putz-Anderson and Galinsky (1993) used psychophysical approach to investigate the effects of various repetition rates, forces, tool weights and reach heights on work durations until a subjectively rated fatigue was reported in repeated flexions of the arm. The repetition rate was the prime determinant for work duration, followed by force, height of target and tool weight.

7. Lack of pauses: Sommerich et al. (1993) summarized findings of recent epidemiological, laboratory and field studies conducted in order to identify occupational risk factors for cumulative trauma disorders of the shoulder region. They identified lack of rest pauses as one of the risk factors associated with shoulder pain. The authors state that Burt et al. (1990) found in their study of shoulder pain in newspaper employees, that cases on average took fewer work breaks than non-cases. Kvarnstrom (1983) investigating assembly workers reported a prevalence ratio of 5.2, as compared to 0.7 for serial assemblers in the same company doing the same task. The only difference was that, as a part of the assembly process, serial assemblers also collected parts and read instructions which allowed their muscles to relax. The assembly line workers, on the other hand experienced no such breaks in their normal work

cycle. In some studies, rest pauses, even in the form of small or micro breaks, was found to be important. Kilbom and Persson (1987) followed two groups of female employees who performed short cycle tasks. They found that the percentage of the work cycle which the workers spent resting (micro-breaks) was inversely related to the occurrence of tendinitis and myofacial syndrome in the second year of employment. It is interesting to note that this data did not appear in the first year of follow-up.

8. Vibration: An exposure-response relationship between cumulative exposure to vibration and shoulder tendinitis have been observed in a study done by Stenlund et al. (1993). The assessment of cumulative exposure took into consideration the hours that each vibrating tool had been used.
9. Draft: Only some epidemiological evidence exits for the association of air velocities and shoulder or neck pain. The behavior of shoulder muscles was studied in an experiment with different air velocities in an office environment (Tola et al., 1988). The myoelectrical activity changes suggests an increased recruitment of motor units in some muscles and a cooling effect due to increases air velocity in other muscle regions.

1.4.1 Overhead work and fatigue

Out of all the physical risk factors identified above, an overhead work posture is most important risk factor relevant to this study. It is very important to understand the underlying mechanism of fatigue and which muscles are most affected by it during overhead work. Also the fact that fatigue can be one of the most detrimental factors for taking breaks during overhead static postures makes the following discussion imperative.

When a skeletal muscle fails to maintain a required force of contraction it is fatigued. In Bjelle et. Al (1979) study of industrial workers, it was found that work positions demanding elevated arm in manual work were a significant factor in noninflammatory prolonged shoulder-neck disorders. One study by Hagberg (1981) determined which muscles in the elevated arm position are likely to develop electromyographic signs of muscle fatigue and how fast these signs develop. He found that the supraspinatus muscle was the first to show signs of electromyographic fatigue and started within a fraction of a minute in the arm elevated position. He states that the reason for the supraspinatus muscle to be the first to show signs of fatigue is not only the fact that it is the most important stabilizer but also due to constant traction on its tendon. This traction may cause an impairment of the nutrition and circulation of the tendon which highly accelerates the fatiguing process. The upper trapezius also showed signs of fatigue during the first 5 minutes in the elevated arm position.

During static contractions, such as in overhead work, intramuscular pressure is reported to increase in proportion to the force of contraction. This increase in intramuscular pressure may be of such magnitude as to impair or impede or even block the muscle blood flow (Kilbom & Persson, 1982). Insufficient blood flow may in turn cause muscle fatigue and thus limit the time for which the contraction can be maintained.

1.5 MSD and non-physical risk factors

1.5.1 General non-physical risk factors

In addition to the physical and task related factors which were discussed earlier, risk of developing MSD/CTD has also been shown to increase due to certain personal factors such as age, gender, personality etc. But these individual risk factors may contribute indirectly to the etiology of MSDs rather than contributing directly to the risk of developing MSD/CTD. In other words, individual factors like behavior, work pattern etc may manifest themselves and cause the individual to behave in a certain way such that they exhibit physical work characteristics which have been previous identified as physical risk factors for MSDs. Lack of social support and outcome of cumulative trauma disorder has been shown to have a positive relationship in many studies (Moon & Sauter, 1996). A comprehensive and systematic review of the literature to identify the most important psychosocial factor by Ariens et al. (2001) suggest that there is some evidence that there is a positive relationship between neck pain and high quantitative job demands, poor social support, low job control, low skill discretion and low job satisfaction. They also found in conclusive evidence of relationship between neck pain and poor supervisor support, conflicts at work, low job security and limited rest break opportunities. Ariens et al. (2001) state that Bergqvist et al. (1995) in their cross sectional study reported an odds ratio of 7.4 for the relationship between “limited rest break opportunities” and neck pain. A review of literature on psychosocial factors effecting neck and shoulder disorders by Bongers et al. (1993), reported a positive relationship between psychosocial variables such as monotonous work, time pressure and high work load. They also state that combination of lack of social support and physical load at work increase the prevalence of neck or shoulder symptoms.

The way that psychosocial factors contribute to the occupational injury is still ambiguous. Most of the previous studies focused primarily on the psychosocial work factors like work load, job satisfaction, and social support. It seems very plausible that some or most of these psychosocial factors may be affected or related to various individual trait characteristics such as personality type, coping style, etc. The approach that each person takes to perform a task may be influenced by a number of individual factors such as personality, work-style, etc. These individual trait characteristics have been studied and investigated quite frequently in the past. But the results of findings have been very often ambiguous and contradictory.

A number of questions regarding these individual factors still remain unanswered. How does each of these individual factors contribute to the injury process? And do any of the individual factors (like personality traits) have any indirect influence on any of the physical factor identified to be potential risk factors for MSDs? The specific characteristic explored in the current study is personality type and is therefore covered in more detail in the following section.

1.5.2 Type A personality

Type A behavior is defined by Friedman & Rosenman (1974) as a behavior that can be observed in any person who is constantly struggling to achieve more and more in less and less time, and in order to achieve more, even go to the extent of opposing others. These people or individuals were also referred to this type of behavior as “coronary-prone behavior pattern” when this concept was introduced in the late 1950s. Competitiveness, ambition, high performance standards, hurried motor and speech patterns, aggressiveness, time urgency, and impatience are some of the characteristics of a typical type A individual (Dembroski et.al, 1979; Gastorf, 1981; Hart & Jamieson, 1983, Jenkins et.al., 1967; Jenkins et.al., 1971; Lambert et.al., 1987; Price, 1982).

Some researchers have found that type A individuals experience more frequent tense, hyperactive movements, vigorous voice and psychomotor mannerisms, restlessness, alertness, a general appearance of tension and restless motor mannerisms. (Sparacino,1979; Dembroski et al., 1979; Jenkins et al., 1971; Jamal, 1985; Jenkins et al., 1967). Bingham and Hailey (1989) state that Gastrof (1980) found that type A’s arrived for appointments much earlier than the scheduled time as compared to type B’s. Yarold and Grimm (1982) found that Type A’s completed questionnaires more quickly than type B’s. All these social interactions can all be interpreted as being the result of type As being impatient and/or being in a hurry which is known as the “time-urgency” component of type A behavior pattern.

The implications of personality type on work related musculoskeletal disorders has also been considered in various studies. Malchaire et al. (2001) reviewed and summarized all epidemiological studies done in the past 15 years relating to various risk factors associated with musculoskeletal disorders or complaints of the neck and upper limbs. They found a few studies (Bru et al., 1993; Flodmark & Aase, 1992; Salminen et al., 1991) where there was a greater incidence of neck-shoulder disorders for type A personality individuals. These studies indicate a positive association between neck-shoulder disorder and personality type and there is a definite need for more investigation in the relationship between neck-shoulder disorder and personality type. Since it can be assumed that personality type remains stable over time (as compared to other psychosocial factors), understanding the possible contribution of personality type on the occupational injury-proneness can be very beneficial and insightful.

The theory that type A individuals negatively impact their social support can be supported by the study done by Burke (1984), in which he concludes that although type A individuals invest more of themselves in their jobs, they are not necessarily more satisfied with their jobs and may be even at the risk of personal and social alienation and disappointment. He also suggests that type A men may have less satisfying and successful marriages and have few intimate friendships. This type of social behavior and interaction can be attributed to some of the type A characteristics like aggression and competitiveness. Marras et al. (2000) found in their study that there was a potential biomechanical pathway associated with psychosocial stress and that, certain individual factors like gender and personality traits may actually increase the stress effect. One of the other findings of this study was the fact that personality traits may be responsible for spine loading differences due to stress. Different personality types responded to psychosocial stress in very different ways. Because people having different personality traits respond differently to psychosocial stress, a physical task or job may be more stressful to one personality type than another, thus increasing the lower back disorder risk. All these findings collectively suggest that there might be some complex relationship between stress and personality type, and how individual factors influence one's risk of developing MSDs.

1.5.3 Personality and workstyle:

Based on the discussion in the earlier section about type A behavior pattern, type A individuals are likely to approach their work very differently in terms of postures, technique, movement, etc. Jamal (1985) state that type A's, in their general approach to work, put more effort in their work activities than do type B's. Jamal also state from Glass (1977) that type A's prefer to be in control of their environment, which brings out type A behavioral characteristics that make people stress-prone (eg., time urgency, hostility towards slowness). All these findings and more indicate that personality type may essentially affect workstyle and since workstyle determines how you behave or perform a task (work-related risk factors), it might indirectly influence an individual's proneness to injury/MSD.

1.5.4 Contribution to injury/illness

A lot of work has been done during the last 40 years looking at various characteristics of type A personality behavior. The primary focus of most of these studies was to discuss or investigate the association between type A personality and coronary heart disease. And these studies have indicated that type A's are more likely to have heart attacks (Burke, 1984). Fields et al (1990) investigated and followed forty runners to determine whether personality type makes them more prone to injuries. They found that athletes who scored high on the type A Self Rating Inventory (TASRI) (Blumenthal et al., 1985) had significantly more injuries and multiple injuries than the type B's. Gill, Henderson and Pargman (1995) suggest that type A athletes may be at high risk of chronic injuries since they may ignore symptoms of stress or injury that interfere with their performance.

More pertinent to the current work are studies that have considered musculoskeletal effects significant to personality type. Glasscock et al. (1999) found that personality type A individuals exhibit increased muscular antagonism as compared to type B individuals. They suggest that this antagonist activity in type As may be present to ensure that they perform the task to perfection. They also suggest based on their results that since personality type has a direct affect on muscle coactivation, it could directly impact the biomechanical loading of the tissues. This linkage suggests that personality type may have a direct impact on the likelihood of getting injured due to increased biomechanical loading of the tissues. Marras et al.

(2000) found in their study that personality and other individual traits may also play a role in an individual's susceptibility to MSD risk factors. In other words, they potentially influence the biomechanical response to psychosocial stress which further elevates the risk for developing MSDs. They found that some personality traits under stressful conditions were responsible for increased spine loading, which increases lower back disorder risk. Wickstrom et al. (1989) and Salminen et al. (1991) based on their studies have suggested a positive relationships between type A behavior and experience of back pain and neck/shoulder discomfort. Bongers et al. (1993) in their review of studies done also state that some studies indicate a positive relationship between type A behavior and back pain (Flodmark & Aase, 1992; Hagg et al., 1990).

1.6 Specific aim of this study

The time-urgency component of the type A behavior pattern may be very critical in influencing how many breaks they take and their duration, while doing occupational tasks. In other words, type As may not take enough breaks as compared to type Bs while performing a job, demanding awkward and static postures, heavy work, etc. This characteristic can be very detrimental, especially while carrying out task requiring breaks to relax the muscles. The importance of taking appropriate rest pauses and their influence on the risk of developing MSDs have been discussed in the earlier section. Thus type A individuals can contribute to the pathology of MSD by indirectly influencing the risk factors which are associated with it (MSDs). No studies have been done so far comparing type As and Bs while doing a pain inducing task (due to static posture) and their approach to such a task given the freedom for taking breaks or rest pauses. The effect of personality type on the general approach to this kind of work and its influence on task performance and rest-work schedule will be the primary focus of this study.

1.6.1 Hypotheses

Hypothesis 1: Type As will work faster than type Bs under painful conditions

The foundational literature regarding personality type would indicate that type As would work faster than type Bs in general. But no studies have tried to look at their work pattern or speed under painful condition. The hypothesis here is that even under painful condition type As will continue to outperform type Bs in terms of speed. The dependent variable important here is the average cycle time for completing a task. The null hypothesis is that there is no difference in the average cycle time between the type A and type B subjects and the alternative hypothesis is that the type B subjects will have a longer cycle time.

Hypothesis 2: Type As will take fewer breaks than type Bs.

The time urgency characteristic of type As will make them take fewer breaks. In other words, just to get the overall task done as soon as possible, type As will take fewer breaks. The dependent variable important here is the number of breaks taken during the work activity. The null hypothesis is that there is no difference in the number of breaks between the type A and type B subjects and the alternative hypothesis is that the type B subjects will have more breaks.

Hypothesis 3: Type As will take longer breaks than type Bs.

Since type As may take fewer breaks they would need longer rest pauses to get to a steady pain level so that they can continue their task. Type Bs on the other hand will take regular breaks thus keeping the duration of the breaks shorter as compared to type As. The dependent variable important here average duration of the breaks. The null hypothesis is that there is no difference in the average break time between the type A and type B subjects and the alternative hypothesis is that the type B subjects will have a shorter break time.

2. Methods

2.1 Participants

Males between the age of 18 and 26 were contacted through the use of fliers, word of mouth and from classes/labs in the Department of Industrial Engineering other departments across the campus. All interested candidates were prescreened by the Jenkins Activity Survey (JAS) (please refer Appendix A and "survey" section for details). A total of 25 male students took the JAS, from which 16 were selected for the second phase of the study. Type As and type Bs were equally recruited (8 each) for the 2^{nd} phase. Second phase subjects were required to have no surgery or problems in their neck and shoulder regions in the past or present. They also were required to have no major physical disability especially motor skills or discomfort before doing the experiment. Before starting either phase they were informed that they will be given a T shirt upon successful completion of the 2^{nd} phase. Before starting both the phases of the study they were required to sign a informed consent form, shown in Appendix B & C. Some basic anthropometric data that were collected during the 2nd phase of the study are listed below:

Table 1 Anthropometric data

Group		Age (years)	Forearm circumference (inches)	Upperarm circumference (inches)	Arm length (inches)	Stature (inches)
Type A	Average	24.1	10.4	10.4	28.7	68.1
	Std dev	0.99	0.77	0.92	1.71	2.64
Type B	Average	24.4	10.7	10.5	28.7	68
	Std dev	1.60	0.80	0.90	1.43	1.51
Whole group	Average	24.2	10.6	10.4	28.7	68.1
	Std dev	1.30	0.77	0.88	1.52	2.08

In addition to the anthropometric information listed in the above table, subjects were asked about their exercise routine and if they considered themselves as someone who is involved in active sports or works out in the gym at least 3 times a week.

2.2 Experimental design

2.2.1 Independent variables

Personality type was the independent variable for this study. This variable consisted of two levels: type A and type B.

2.2.2 Dependent variables

Various dependent variables that were recorded/collected during the study are listed below:

1. Total cycle time (in seconds): total time from the start of the session to the very end when they completed all of the 40 cycles. $\sum$ Cycle times + $\sum$ Break time

2. Total break time (in seconds): sum of all break times (time from the instant the subject puts his hand all the way down after the end of a cycle to the instant when he starts the next cycle) each subject took as a part of the total cycle time. $\sum$ Break time
3. Average cycle time (in seconds): the average of the actual cycle time (Time from the instant the subject starts a cycle to the instant when he ends the same cycle) spent doing the task. ($\sum$ Cycle time)/40
4. Average break time (in seconds): the average of the actual breaks each subject took during the whole session based on number of breaks.

$$\frac{\sum \text{Break time}}{\text{\# of breaks}}$$

5. # of breaks: total number of breaks each subject took while performing the 40 cycles.
6. Average break for 39(in seconds): the average of the actual breaks each subject took during the whole session based on total # of breaks he could have taken (39). ($\sum$ Break time)/39
7. Average pain scale at breaks (0 to 10): the average of the VAS pain scale whenever the subject took a break. ($\sum$ VAS reading before breaks)/# of breaks
8. Average pain scale (0 to 10): The average pain reported by each subject at the end of each cycle. ($\sum$ VAS reading after each cycle)/40

The anthropometric data and exercise routine (yes or no) also served as covariates in the exploratory analysis.

2.2.3 Experimental design model

The current study used the following statistical model:

$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$; (i = 1-2, j = 1-16)

This model is a fixed effects model with τ being a fixed variable of personality type, 1 (A) or 2 (B).

2.3 Instruments

2.3.1 Survey

Personality type was assessed and determined using the modified student version of the Jenkins Activity Survey (JAS) (Glasscock, PC; Jenkins et al., 1979). The JAS is forced response survey containing 52 questions about behavioral tendencies (see appendix A). The original survey was modified by Glasscock (1999 and Personal Communication) to include both the working class as well as the student population. There are different scores which are generated using the JAS, but only type A score was used for prescreening the participants for the second phase of the study.

The scoring of personality type is on a scale, which goes from 0 percentile representing the most type B to 100 percentile which is the most type A. The subjects were selected from two extremes of the scoring scale in order to increase the reliability of the measure’s assessment. The type B group consisted of subjects who have scored less than 35 on the JAS percentile scale. The type A group consisted of subjects who scored more than 65 on the JAS percentile scale.

2.3.2 Experimental Apparatus

The 2^{nd} phase task was an overhead assembly task consisting of screwing and unscrewing three nuts onto bolts affixed to a wooden board. As shown in the Figure2, the wooden board (Figure3) was mounted on a height adjustable wooden frame. The setup also had two trays of bolts and nuts, right beside the wooden board, in case the subjects dropped them while doing the task (please refer Figure 2 & 4). The wooden frame also had a Visual Analog Scale (VAS) (refer appendix D) displayed close to the wooden board for the subjects. The position of the VAS was adjusted for each subject so that they can read it clearly while doing the task and without changing the neck posture.

Stop watch was used to record the timings for the various dependent variables listed in the previous section. All the subjects were video taped while performing the task and this video data was used to analyze the break pattern and other time related data which were not collected during the actual experimental session.

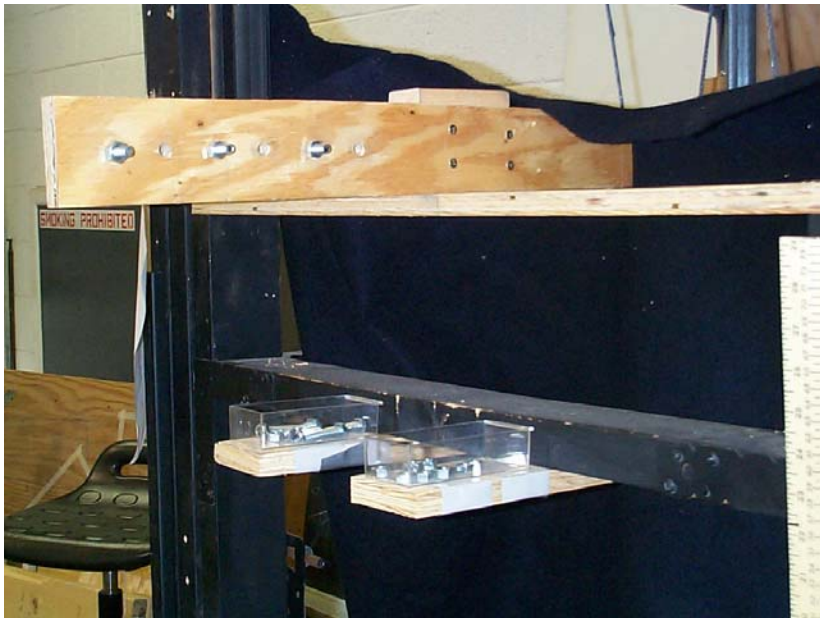


Figure 2 Setup of the apparatus

Figure 3 Wooden board

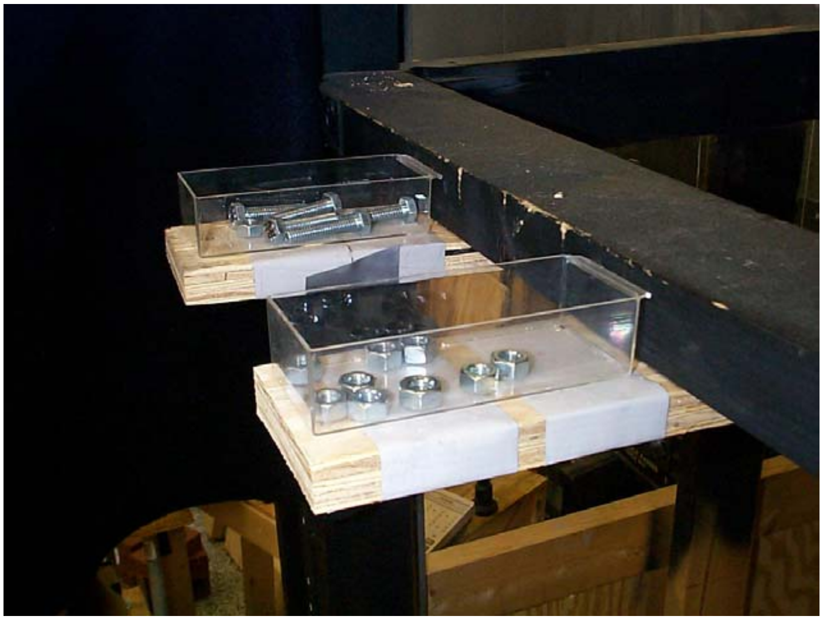


Figure 4 Trays for nuts and bolts

2.4 Experimental procedures

2.4.1 Phase I: Prescreening

Subjects who have communicated their interest in participating in the study were asked to complete the Jenkins Activity Survey (JAS) (see Appendix A). Before filling the survey they were instructed on how to fill out the survey and they had to sign the informed consent form. Any questions regarding the survey were answered at this point.

2.4.2 Phase II: Overhead assembly task

Upon arrival into the laboratory, the purpose of the experiment (Assessing work style during an overhead work task) was briefly explained to the participants. The real purpose and scope of the study were never disclosed to the subjects since it might have biased their behavior during the task. Participants were asked to read the informed consent form. Those who wish to continue signed the informed consent form (refer appendix C) and provided it to the investigator. Participants who wished to retain a copy of the unsigned consent form were provided a copy to take with them. Anthropometric measurements were then taken using anthropometer. The subjects were then asked about their exercise routine and whether they would describe themselves as someone who goes to the gym regularly or plays sports. The height of the board was adjusted by asking the subject to extend his arms directly overhead and aligning the wooden board's upper edge with the subject's wrist (refer Figure 5).

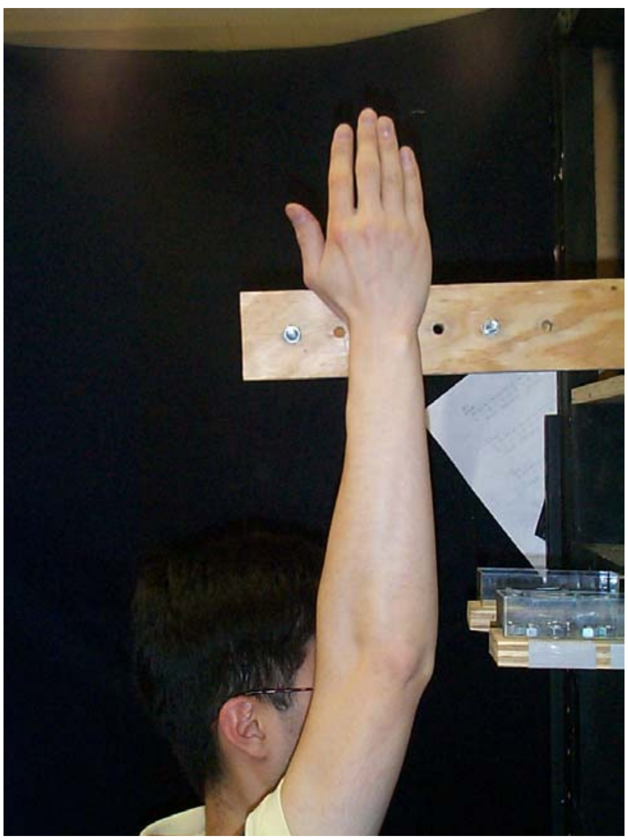


Figure 5 Height adjustment posture

2.4.3 Introduction and training

Introductory Script:

Today, you will be asked to a task that is similar to those seen throughout industry. It is important that you approach the task as you would if you were actually asked to perform the task in the workplace. You will be given specific instructions prior to beginning the task.

Task training: Prior to the actual data collection phase, subjects were introduced to the tasks that they would be performing and asked to maintain a standard technique throughout the experiment. The experimenter demonstrated the task to them and introduced the VAS (refer appendix D) to the subjects. They were then asked to do 2 practice cycles to get used to the task and encouraged to any ask question regarding the task.

Procedure script:

You are required to complete 40 cycles and each cycle entails unscrewing the bolts, screwing them to the next hole and starting back from the first bolt putting back all the 3 bolts in its initial position or hole. While doing the task please try not to drop any nuts or bolts bit in case you do, don't bother to pick them up from the floor. Just get one from the trays which are mounted close to the wooden board. At the end of each cycle please look at the VAS scale that is affixed near the wooden board and based on your discomfort at that particular instant give me a number from 0 to 10. Continue to do the cycles, if needed while giving the discomfort scale rating. As soon as you complete 40 cycles you will end this session and leave this room. Please try to do the task the way it was shown to you and try to keep a consistent technique throughout the session. You can take breaks after completion of each cycle but not within a cycle. Each break can be as long as you want but remember the fewer and *smaller breaks you take the sooner you will get done with the 40 cycles and will be relieved. I will give you a count down of the cycles remaining to complete the session after each cycle.*

2.4.4 Description of the Assembly task

The task was an overhead assembly task (see Figure6) of screwing bolts onto a wooden board. The height of the board was setup for each individual based on his anthropometry as explained above. Subjects were instructed about the technique to be used and were also be given a few practice trials before the actual task. They were told to keep a consistent work technique throughout the session. Subjects were asked to perform this task as if they are doing it for an 8 hr shift and they were told that they could leave as soon as they finished the 40 cycles. One cycle represents unscrewing bolts, screwing them in the next hole on the board, unscrewing them again and putting them back in its original or initial position/hole. Data was collected after every completed cycle during the task regarding their discomfort ratings on a Visual Analog Scale (VAS).

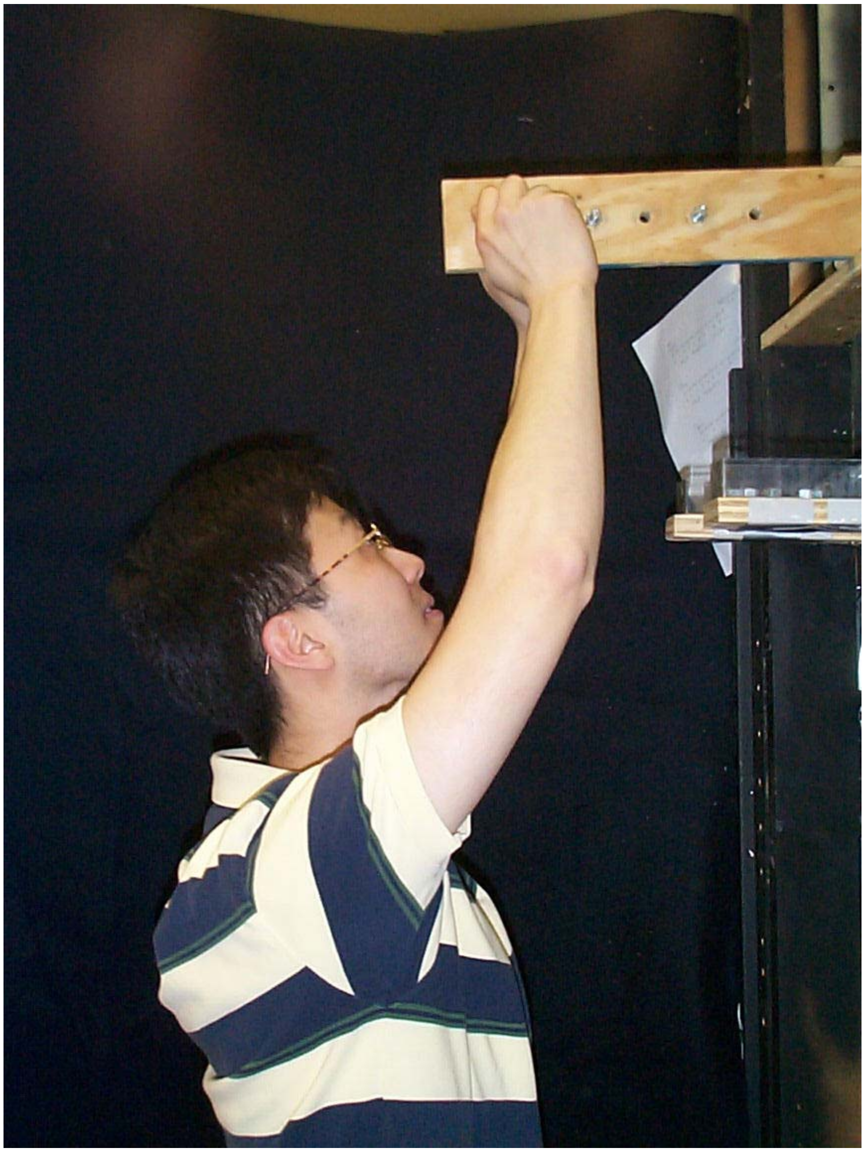


Figure 6 Working overhead posture

2.5 Data processing

Phase I:

All responses to the JAS questionnaire were entered into an excel spreadsheet and text file. They were then processed by a computer data processing program to calculate the final personality score. This final score was then entered into the database and depending on whether they qualified or not, subjects were contacted and invited to participate in the second phase.

Phase II:

All dependent variables for each subject were entered into an excel spreadsheet. These were then complied together into a text file with all relevant information. This was then processed by SAS for ANOVA results.

2.6 Statistical Data Analysis

2.6.1 ANOVA Assumptions

Before analyzing the data, it is assumed that the residuals from the statistical model are normally distributed (normality) and they have equal variances (homogeneity). Also the independence or randomness of the data was assumed by random subject selection and recruiting them as they responded to the JAS on a first-come-first-serve basis.

The normality of the residuals was tested using the Shapiro-Wilk test and a graphical assessment of the distribution of residuals. The homogeneity of the variances was tested using the graphical assessment by plotting residuals versus the fitted value and also Bartlett test ($p \leq 0.05$). Test results of both of the assumptions of ANOVA are discussed in the "Results" section of this document.

2.6.2 ANOVA

ANOVA procedures were used to assess the impact personality type had on the performance characteristics. An effect was said to be significant if the p value was less than 0.05.

3. Results

3.1 Testing ANOVA assumptions

The normality of the data was tested by looking at the distribution of the residuals of the responses (Table 2). Two of the residual responses had a p value of less than 0.05 which meant that the normality assumption of ANOVA was in question (refer table 2 for details).

Table 2 Normality & Homogeneity tests

Responses	Shapiro-Wilk W Test		Bartlett	
	W	Prob<W	F ratio	Prob>F
Residual total cycle time	0.891196	0.059	0.5804	0.4462
Residual avg. cycle time	0.845292	0.011	3.7392	0.0532
Residual breaks	0.914584	0.14	1.2558	0.2624
Residual avg. break time	0.645152	<.0001	11.44	0.0007
Residual avg. break for 39	0.937947	0.322	0.0324	0.8571
Residual total break time	0.937959	0.322	0.0325	0.8568
Residual avg. pain scale	0.968454	0.7824	1.0978	0.2948
Residual avg. pain scale at breaks	0.907583	0.108	0.0738	0.7859

Looking at the residual average cycle time and the residual average break time distribution (refer appendix E), one can see that both the distributions are skewed because of one data point. Montgomery (1984) notes that moderate departures from normality that result from a skewed distribution represent only a minor violation of this assumption in the fixed effects analysis of variance and the procedure is quite robust in this regard. Therefore the normality assumption was found not to be violated in this dependent variable.

The graphical assessment of the homogeneity assumption for the residual average break time which was found to be suspect using the Bartlett test, showed no systematic trend in these variances (Appendix F) Since the plot does not show any obvious pattern or trend, the homogeneity of variances assumption is upheld (Montgomery, 1984).

3.2 ANOVA results

After testing the ANOVA assumptions for normality and homogeneity, the ANOVA was conducted for the whole model. The results of this analysis found that there was no significance effect of personality type on task performance (refer table 3). The means and the standard deviations for each of the dependent variables are also listed in Table 4.

Table 3 ANOVA results for the whole model (all 16 subjects)

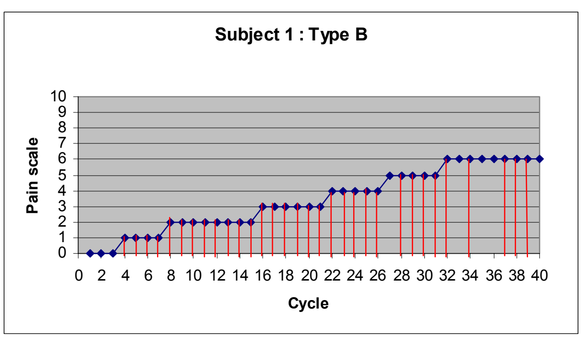
Responses	F Ratio	Prob > F
Total cycle time	1.3014	0.2731
Avg. cycle time	1.0495	0.323
# of breaks	0.493	0.4941
Avg. break time	0.5971	0.4525
Avg. break for 39	0.939	0.349
Total break time	0.9384	0.3491
Avg. pain scale	1.0486	0.3232
Avg. pain scale at breaks	0.3302	0.5747

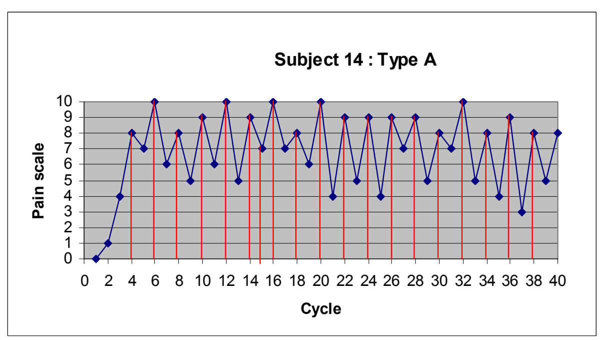
Table 4 Means and std. deviation for all dependent variables

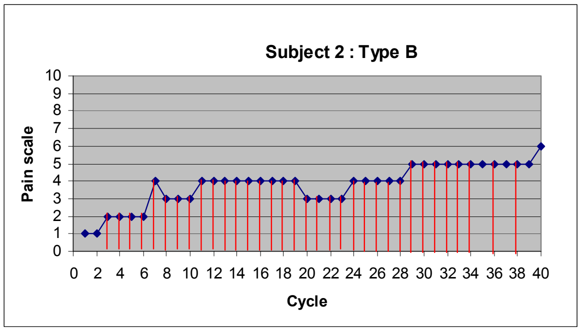
Responses	Means		Std Dev.	
	Type A	Type B	Type A	Type B
Total cycle time (sec)	3175.63	3175.63	792.73	587.12
Avg. cycle time (sec)	58.50	53.38	12.86	5.82
# of breaks	28.13	23.88	9.23	14.42
Avg. break time (sec)	30.73	48.80	14.10	64.62
Avg. break for 39 (sec)	21.43	16.42	9.96	10.69
Total break time (sec)	835.63	640.38	388.64	417.08
Avg. pain scale	5.85	4.88	2.22	1.47
Avg. pain scale at breaks	6.32	5.63	2.55	2.29

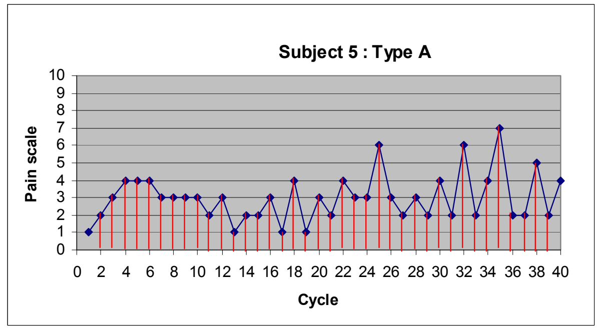
3.3 Individual work pattern

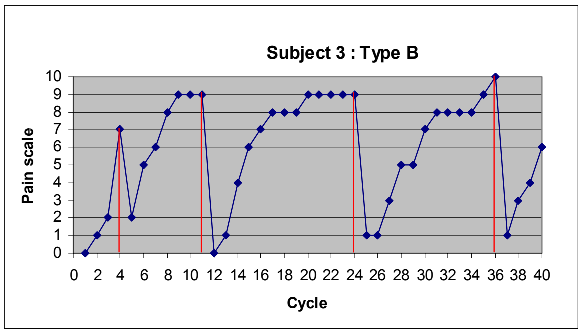
In an effort to better understand the relationship between individuals and their break pattern and the influence of reported pain on breaks, the following graphs of each subject are presented. These graphs have reported pain scale as the y value and the cycle on the x axis. All the red lines running vertically indicate when each subject took a break during the session. Thus the graphs depict the work-break pattern of each individual with reference to the pain level they reported after each cycle.

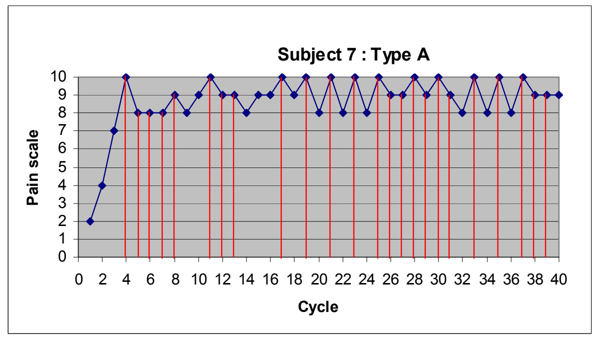


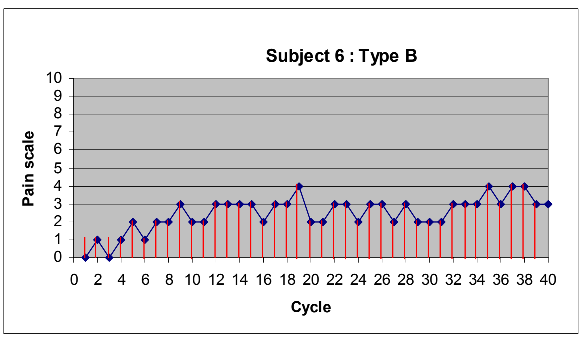


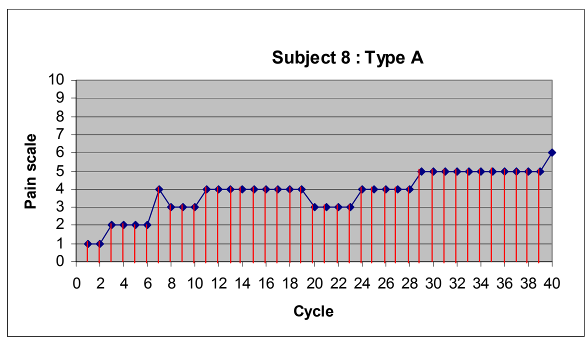

Subject 2 : Type B
Pain scale
Cycle

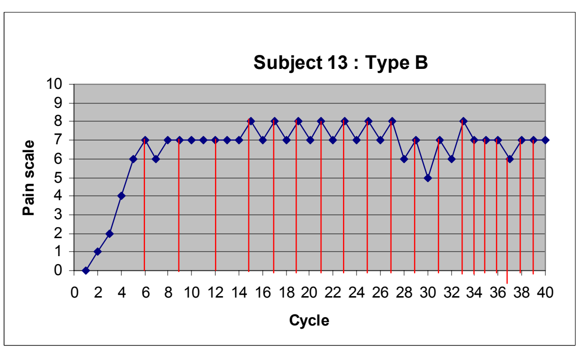

Subject 5 : Type A
Pain scale
Cycle

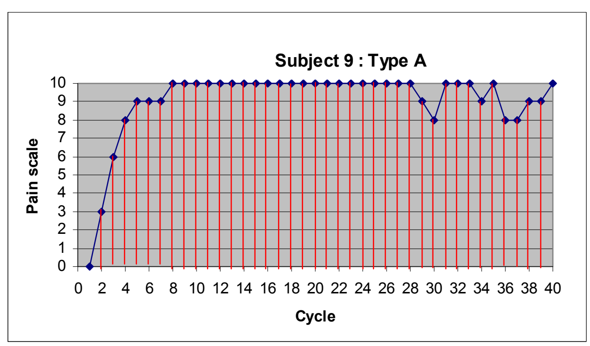

Subject 3 : Type B
Pain scale
Cycle


Subject 7 : Type A
Pain scale
Cycle


Subject 6 : Type B
Pain scale
Cycle


Subject 8 : Type A
Pain scale
Cycle


Subject 13 : Type B
Pain scale
Cycle


Subject 9 : Type A
Pain scale
Cycle

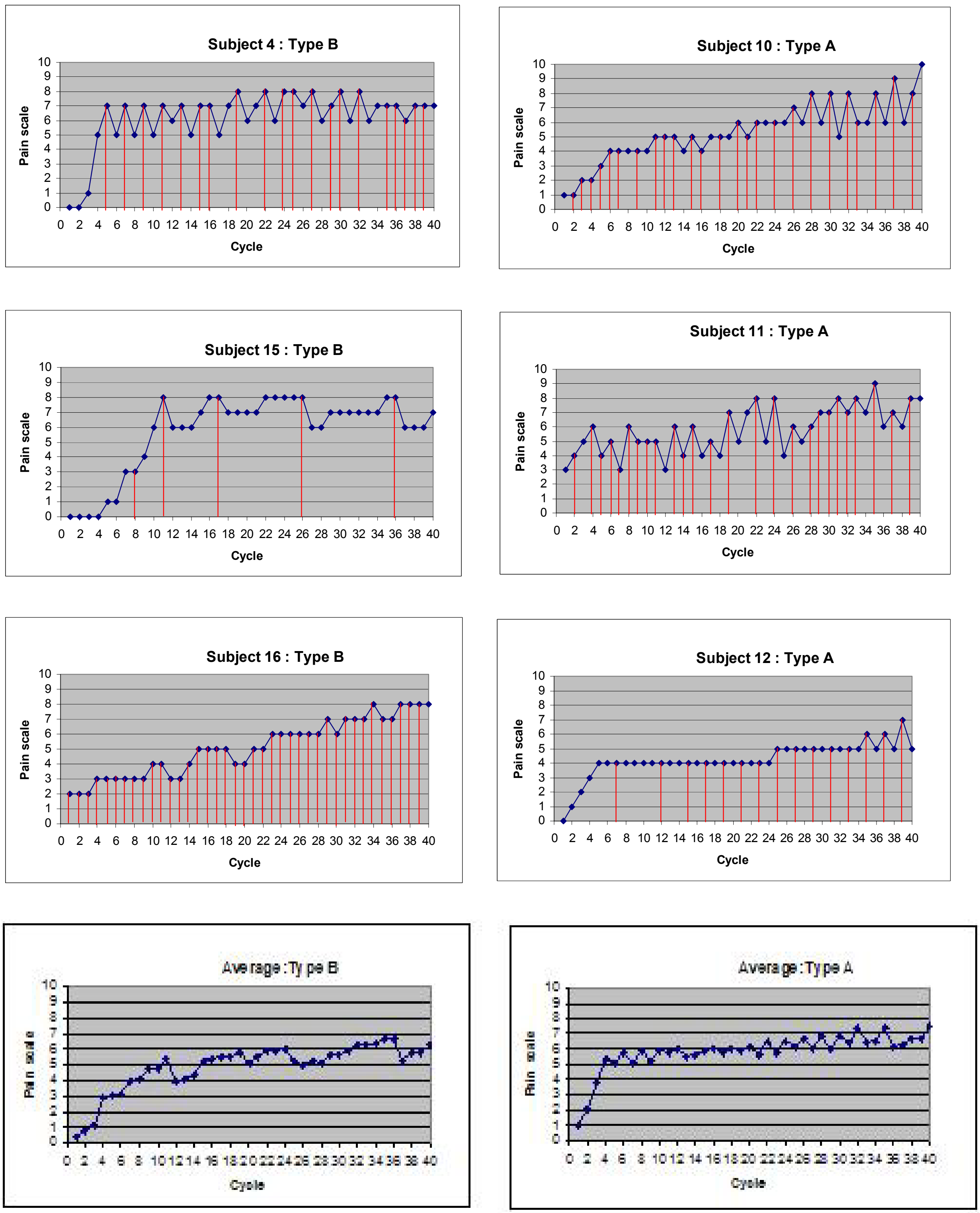


Figure 7 Type A vs. type B work pattern for all 16 subjects

From the graphs above, one can see there is so much variability in the way individuals take breaks and there doesn't really seem to have any particular pattern or criteria to take a break (refer Figure 7). The question was "what is the pain scale at which an individual decides to take a break?" But the graphs above really shows that the variability within groups and also across subjects is so high that there is no trend or pattern. This explains why the ANOVA did not show any significant effect of personality type on various dependent variables.

4.0 Discussion

The current study hypotheses were based on the theory that type As outperform type Bs in general due to their inherent characteristics like speed, impatience, aggressiveness, etc. These task related characteristics were based on various studies that suggested type As invest more of themselves in work activities (Jamal, 1985), and type As outperform type Bs on simple tasks (Burnam et al., 1975).

In this current study, however, there was no significant effect of personality type in any of the task performance variables. All three hypotheses were rejected:

- Type As did not work faster than type Bs even when given the freedom (speed controlled by the individual and not by the process).
- Type As did not take fewer breaks as compared to type Bs during the whole session.
- Type As did not take longer breaks then type Bs during the whole session.

These results are not, however, without precedent. One study by Jamal (1985) examined type A and type B differences in job performance among white collar employees. They found no significant difference in type A's and type B's on quantity of performance and promotions obtained during the last 5 years. In a study of life insurance sales personnel, Matteson et al. (1984) reported no significant relationship between type A and sales performance quantity. Glasscock suggests that the nature of the task may be an important consideration (personal communication). She found that there was no significant effect of personality type on simple task performance like pipetting and computer input task, but when performing an assembly of a reciprocating saw (a more complicated multi-step task), that type As outperform type Bs. Similar to these results, Fazio et al. (1981), in their study found that type As outperformed their B counterparts when working on multiple situational demand task conditions. They also suggest that type As when unchallenged and in control tend to expend less effort as compared to when they are challenged. One explanation for such inconsistent findings may be the presence or absence of task variety. To support this theory, Gastorf et al. (1980) found that type As performance levels to be higher than type Bs on difficult tasks but poorer on less complex tasks. This is consistent with the results of the current study which found no significant difference on the performance variables for the two personality types. The monotonous nature of the task and the unchallenged working environment could explain the results of this study.

Glasscock et al. (1999) suggests in their study that the antagonist activity which they found in type As may be present to ensure that they perform the task to perfection. In the current study, it may be possible that this perfectionist component of type A behavior pattern may "override" the time urgency component and influence the type A to spend even more time on the task than type B. This could happen if there is a positive relationship between time-on-task and performance outcome. In the current study, the subjects were expected not to drop nuts while doing the task and this might be conceived by type As as a "performance outcome". Thus they spend more time to make sure that they don't drop any nuts while performing the task. We can infer from the above discussion that if the two major components of type A behavior (i.e. perfectionist and speed/impatience) do interfere with one another and the nature of the task is such that none of these tendencies are made salient then there won't be any major significant differences in the behavior of type As and type Bs.

To expand on why type As did not outperform their type B counterparts, let's look at the various possible factors affecting their performance in context with the current study: motivation, work technique, other individual trait characteristics and biomechanical factor.

One of the intended motivating factors for type As to do the task faster and take fewer breaks was the "40 cycles- go home" factor. It was stressed as much as possible in the procedure script to each subject that as soon as they complete 40 cycles they can go home (or at least leave the session). But it may be possible that type As were not motivated enough (as they were supposed to be) to do the cycles as fast as possible. This could be one of the crucial issues that could have a major impact on the results of this study.

Although the technique used to do the task was kept pretty consistent, there may be some subtle variation in the technique each individual adapted to do the task. This may have a big impact on average cycle time which was one of the dependent variable. Having said that, the procedure script also explained to each subject how they were supposed to do the task (posture, technique, etc) and were clearly instructed to maintain a consistent technique throughout the session.

Another factor which may be influenced by some other individual trait not investigated in this study is the strategy each individual adopted for carrying out the 40 cycles. In other words, each person would develop his own strategy for various component of the task like the number of continuous cycles he would perform before taking a break, etc (refer Figure 7 for details). If the strategy is influenced by some individual factors like coping style, extrovert/introvert but not by the personality type then the results won't show any significance effect, as was the case in this study.

Since the current study results did not show any positive effect of personality type on task performance variables, it may be possible that the personality effect in context with the overhead assembly task was overridden by some other biomechanical response or factor not investigated in this current study. Thus even if type As were in fact trying to perform the task faster then type Bs, they could not do it because of some other biomechanical factor such as fatigue and muscle tension. The kind of data required to look at some other biomechanical response during the task like EMG etc was limited by the scope of this study.

The results of this study provide some insight for jobs which are self paced, especially in industries with a piece rate production system. The finding that there is no positive relationship between personality type and work pattern (break strategies) suggests that the personality type characteristic of time urgency is not always the dominant force in defining the user defined break patterns. It could also imply that type As do not expend more effort on monotonous, unchallenged jobs as compared to their type Bs counterparts.

4.1 Limitations

The fact that the whole session even though presumed to be like a real industrial setting was conducted in a laboratory had its own limitations. The psyche of an industrial worker cannot be induced in graduate students who were majority of the subjects recruited for this study. It would be interesting to study industrial workers in their working environment especially if they have worked more than 10 years doing the same overhead work day in and day out. This vast experience would certainly help them to develop their own strategies to deal with the pain and fatigue associated with overhead work.

Also the incentive for type As to work faster and get done with the whole session could have been low because of the short duration of the experiment. Maybe if they had to do the task for a large number of cycles (work for the whole day), they would have been more motivated to work faster and we could see significant effect of personality type on the task strategies (e.g. # of breaks, break time, etc). So in other words, the behavior or work pattern for a one hour experiment and 8 hours of actual job could have shown very different results. But designing something like a real work environment for the experiment was beyond the scope of this experimental laboratory study.

The task that was selected for this study also had its impact on various important aspects of performance. Trying to keep a consistent technique throughout the session as well as across subjects was one of the major concerns of this study. There are many ways an individual can put a nut onto a bolt and the total time complete one sub-task of the whole cycle fluctuated tremendously even within a subject. One would expect once the learning curve is dealt with, the performance of the subject would settle down, which never happened for most subjects in this study. So the crux of this discussion is that the task could have been some industrial task which would bring out the differences in performance between subjects only due to differences in individual behavior/tendencies. But having said that, the total cycle time or the average cycle time would have smoothened any of the fluctuations due to the nature of the task. And the fact that these dependent variables did not show any significant effect shows that the nature of the task really didn’t influence any of the major dependent variables.

4.2 Future research

One of the findings of this study was that there does not seem to be any positive relationship between personality type and behavior pattern (especially taking breaks during overhead task). This conclusion was based on the data available from the experiment. To confirm this, all future studies should take into account the limitations of this study discussed in earlier sections. A bigger sample size, investigating real industrial workers with vast experience doing their job and recording biomechanical responses such as EMG would bring out any differences if any between the two extreme personality types behavior pattern. Since the current study looked at just one subject at a time, looking at multiple subjects doing the same job (such as in an industry) would be very insightful for industrial applications. This might be particularly interesting to investigate and find how type A performs when they work with other individuals in their environment doing the same task. Does the presence of others challenge type A individuals to the extent that they would expend more effort and in fact improve their performance? would be question asked. As discussed in previous sections, no biomechanical responses were recorded during the study. Absence of such data prevented us from investigating any association between the break pattern or the performance and muscle activity or fatigue. It would have interesting to look at EMG data for the shoulder muscles and superimpose it on the time vs. breaks graph. This would have given us some insight on the biomechanical factors which influence why certain people take regular breaks and why some choose to take fewer breaks. Also the task selected for future studies should be such that it does not cause the two major components of type A behavior (i.e. competitiveness and impatience) do not interfere with each other and the nature of the task should be such that one of these characteristic should be made salient. This kind of experimental design will bring out any major significant differences if they exist.

5.0 Conclusion

The specific aim of this study was to find the effect of personality type on task performance and how personality type would directly influence one's behavior while doing overhead work and linking such specific behaviors (for e.g. taking less frequent breaks) to physical risk factors for MSDs of the shoulder. The outcome of this research have not confirmed to the hypotheses that type As would perform faster, and take fewer and long breaks as compared to type Bs. This does not in any way suggest that type As are less or equally susceptible to MSDs as compared to type Bs. The current study only suggests that the work pattern or break strategy of individuals, while performing an overhead work may be predominately influenced by some factor or factors other than personality type.

References

- Ali E. E. (1979). On the biomechanics of the shoulder complex. Journal of biomechanics, vol.13, 575-590.
- Ariens G. A. M., Mechelen W., Bongers P. M., Bouter L. M., and Wal G. (2001). Psychosocial risk factors for neck pain: A systematic review. American Journal of Industrial medicine 39: 180-193.
- Barbara E. Kent (1971). Functional anatomy of the shoulder complex: A review. Physical therapy, vol.51, 8, August 1971, 867-887.
- Baron S., Milliron M., and Habes D. J. (1990). NIOSH, Health Hazard Evaluation report, HETA, 88-344.
- Bergqvist U., Wolgast E., Nilsson B., and Voss M. (1995). The influence of VDT work on musculoskeletal disorders. Ergonomics 38: 754-762.
- Bingham D., & Hailey B. J. (1989). The time-urgency component of the Type A behavior pattern: time pressure and performance. Journal of applied social psychology, 19, 425-432.
- Bjelle A., Hagberg M., and Michaelsson G., (1979). Clinical and ergonomic factors for prolonged shoulder pain among industrial workers. Scandinavian Journal of environmental health. 5(3): 205-210.
- Blumenthal J.A., Hrman S., O'Toole L.C., & al. (1985). Development of a brief self-report measure of the type A coronary prone behavior pattern. Journal of psychosomatic research, 29(3), 265-274.

- Bongers P.M., De Winter C.R., Kompier M.A., & Hildebrandt V.H. (1993). Psychosocial factors at work and musculoskeletal disease. Scandinavian Journal of Work and Environmental health, 19, 297-312.
- Bradley E., and Rempel D. (1996). The Occupational Ergonomics handbook 1996, chapter 42 *Epidemiology of upper extremity disorders*, Waldemar K., Marras W.S. (Ed).
- Bru E., Mykletun R., Svebak S. (1993). Neuroticism, extraversion, anxiety and type A behavior as mediators of neck, shoulder and lower back pain in female hospital staff. Personal Individual differences, 15, 485-492.
- Bruke R.J. (1984). What makes Sammy run – so fast and aggressively? Beliefs and fears underlying type A behavior. Journal of occupational behaviour, 5, 219-227.
- Burnam M. A., Pennebaker J. W., and Glass D. C. (1975). Time consciousness, achievement striving and the type A coronary-prone behavior pattern, Journal of Abnormal Psychology; 84, 76-79.
- Burt S., Hornung R., & Fine L. J. (1990). NIOSH health hazard evaluation report, HETA, 89-250-2046.
- Culham E., Peat M. (1993). Functional-anatomy of the shoulder complex, Journal of Orthopedic & Sports physical therapy, 18 (1): 342-350.

- Dembroski T.M., Macdougall J.M., & Lushene R. (1979). Interpersonal interaction and cardiovascular response in type A subjects and coronary patients. Journal of human stress, 5, 28-36.
- Dvir Z. and Berme N. (1978). The shoulder complex in elevation of the arm: A mechanism approach. Journal of biomechanics, vol.11, 219-225.
- Edwards R. H. T. (1988). Hypotheses of peripheral and central mechanisms underlying occupational muscle pain and injury, European journal of applied physiology and occupational physiology, 57 (3): 275-281.
- Evanoff B. and Rempel D. (1996). The Occupational Ergonomics handbook 1996, chapter 42 *Epidemiology of upper extremity disorders*, Waldemar K., Marras W.S. (Ed).
- Fazio R. H., Cooper M., Dayson K., and Johnson M. (1981). Control and the coronary-prone behavior pattern A: responses to multiple situational demands, Personality and social Psychology bulletin, 7, 97-102.
- Fields K. B., Delaney M., & Hinkle J. S. (1990). A prospective study of type A behavior and running injuries. Journal of family practice, 30(4), 425-429.
- Flodmark B., & Aase G. (1992). Musculoskeletal symptoms and type A behavior in blue collar workers. British Journal of Industrial Medicine, 49, 683-687.
- Friedman M., & Rosenman R.H., (1974). Type A behavior and your heart. New York: Alfred A. Knopf, Inc.

- Gastorf J. W. (1980). Time-urgency of the type A behavior pattern. Journal of consulting and clinical psychology, 48, 299.
- Gastorf J. W., Suls J., and Sanders G. S. (1980). Type A coronary-prone behavior and social facilitation, Journal of Personality and Social Psychology, 38, 773-780.
- Gastorf J.W., (1981). Physiologic reaction of type A's to objective and subjective challenge. Journal of human stress, 7, 16-20.
- Gill K., Henderson J., & Pargman D. (1995). The type A competitive runner: At risk for psychological stress and injury? International Journal of sport psychology, 26(4), 541-550.
- Glass J. M. (1976). Organization and action – Excecutives personality type as a pathological formation. Journal of contemporary business, 5(4), 91-111.
- Glasscock N. F., Turville K. L., Joines S. B., & Mirka G. A. (1999). The effect of personality type on muscle coactivation during elbow flexion, Human factors, 41, 51-60.
- Hagberg M. (1981). Electromyographic signs of shoulder muscular fatigue in two elevated arm positions, American journal of physical medicine, Vol.60, 3, 111-121.
- Hagberg M., and Wegman D.H. (1987). Prevalence rates and odds ratios of shoulder-neck diseases in different occupational groups, British Journal of Industrial medicine, 44, 602-610.

- Hagg G.M., Suurkula J.,& Kilbom A. (1990). Predictors for work related shoulder/neck disorders: a longitudinal study of female assembly workers. Stockholm, Arbetarskyddsverket.
- Hart K.E. & Jamieson J.L. (1983). Type A behavior and cardiovascular recovery from psychosocial stressor. Journal of human stress. 9, 18-24.
- Hendrick H.W. (1993). The IEA and international ergonomics: Past, present and future. In O.Brown, Jr. (Ed.), *Ergonomics in Russia, the other independent states, and around the world*, Volume 2 (pp. 1-12). St Petersburg: Russian Ergonomics Association.
- Herberts P., Kadefors R., Andersson G., and Petersen I. (1981). Shoulder pain in industry: An epidemiological study on welders. Acta Orthop. Scandinavian 52(3): 299-306.
- Herberts P., Kadefors R., Hogfors C., and Sigholm G. (1984). Shoulder pain and heavy manual labor, Clinical Orthopaedics and related research, 191, 166-178.
- Jamal M. (1985). Type A behavior and job performance: some suggestive findings. Journal of human stress, 11, 60-68.
- Jarvholm U., Palmerud G., Kadefors R., Herberts P. (1991). The effect of arm support on the supraspinatus muscle during simulated assembly work and welding., Ergonomics, 34(1): 57-66.

- Jenkins C.D., Rosenman R.H. & Friedman M. (1967). Development of an objective psychological test for determination of the coronary-prone behavior pattern in employed men. Journal of chronic disorders, 20, 371-379.
- Jenkins C.D., Rosenman R.H. & Zyzanski S.J. (1971). Progress toward validation of a computer-scored test for the type A coronary-prone behavior pattern. Psychosomatic medicine, 33(4), 193-202.
- Kilbom A. and Persson J. (1982). Leg blood flow during static exercise, European journal of physiology, 48, 367-377.
- Kilbom A., and Persson J. (1987). Work technique and its consequences for musculoskeletal disorders, Ergonomics, 30, 273-279.
- Kroemer K.H.E. (1989). Cumulative trauma disorders: Their recognition and ergonomics measures to avoid them Applied Ergonomics, Vol 20, 4, 274-280.
- Kvarnstrom S. (1983). Occurrence of musculoskeletal disorders in a manufacturing industry with special attention to occupational shoulder disorders, Scandinavian Journal of Rehabilitation Medicine, suppl. 8, 1-114.
- Lambert W.W., MacEvoy B., Klackenberg-Larsson I., Karlberg P., & Karlberg J. (1987). The relation of stress hormone excretion to type A behavior and to health. Journal of human stress, 13, 128-135.
- Lucas B. D. and Inman V. T. (1957). Functional anatomy of the shoulder joint, Unpublished, University of California.

- Luopajarvi T., Kuorinka I., Virolainen M., and Holmberg M. (1979). Prevalence of tenosynovitis and other injuries of the upper extremities in repetitive work. Scandinavian Journal of work environmental health, 5, 48-55.
- Malchaire J., Glass N., & Vergracht S. (2001). Review of the factors associated with musculoskeletal problems in epidemiological studies. Int Arch Occup Environ Health, 74, 79-90.
- Marras W. S., Davis K. G., Heaney C. A., Maronitis A. B., & Allread W. G. (2000). The influence of psychosocial stress, gender, and personality on mechanical loading of the lumbar spine, Spine, Vol 25 (23), 3045-3054.
- Mathiassen S., (1993). The influence of exercise/rest schedule on the physiological and psychophysical response to isometric shoulder-neck exercise., European Journal of applied physiology, 67(6): 528-539.
- Matteson M. T., Ivancevich J. M., and Smith S. V. (1984). Relation of type A behavior to performance and satisfaction among sales personnel, Journal of vocational behavior, 25, 203-214.
- Moon S.D., & Sauter S.L. (Eds.) (1996). Beyond biomechanics: Psychological aspects of musculoskeletal disorders in office work. Bristol, Taylor & Francis.
- NIOSH (1996). National Occupational Research Agenda. DDHS Publication No. 96-1115. National Institute of Occupational Safety and Health. Cincinnati, Ohio.

- Peat M. (1986). Functional-anatomy of the shoulder complex, Physical therapy, Vol.66, 12, 1855-1865.
- Price V.A. (1982). Type A behavior pattern: a model for research and practice. New York: Academic press.
- Putz-Anderson V., and Galinsky T.L. (1993). Psychophysically determined work durations for limiting shoulder girdle fatigue from elevated manual work. International journal of industrial ergonomics 11(1): 19-28.
- Sakakibara H., Miyao M., Kondo T., and Yamada S., (1995). Overhead work and shoulder neck pain in orchard farmers harvesting pears and apples. Ergonomics 38(4): 700-706.
- Salminen J.J., Pentti J., & Wickstrom G. (1991). Tenderness and pain in neck and shoulders in relation to type A behavior. Scandinavian Journal of Rheumatology, 20, 344-350.
- Schuldt K., Ekholm J., Harms-Ringdahl K., Nemeth G., and Arborelius U.P. (1987). Effects of arm support or suspension on neck and shoulder muscle activity during sedentary work. Scandinavian Journal of rehabilitation medicine., 19(2): 77-84.
- Sigholm G., Herberts P., Almstrom C., and Kadefors R. (1984). Electromyographic analysis of shoulder muscle load. Journal of Orthop. Res. 1(4): 379-386.

- Sommerich C. M., McGlothlin J. D., & Marras W. S. (1993). Occupational risk factors associated with soft-tissue disorders of the shoulder- A review of recent investigations in the literature. Ergonomics, 36(6), 697-717.
- Sparacino J. (1979). The type A behavior pattern: a critical assessment. Journal of human stress, 5, 37-51.
- Stenlund B., Goldie I., Hagberg M., Hogstedt C. (1993). Shoulder tendinitis and its relation to heavy manual work and exposure to vibration. Scandinavian Journal of work environmental health 19(1): 43-49.
- Stenlund B., Goldie I., Hagberg M., Hogstedt C., and Marions O. (1992) Radiographic osteoarthrosis in the acromioclavicular joint resulting from manual work or exposure to vibration. Br. Journal of industrial medicine, 49 (8): 588-593.
- Thompson A, Plewes L, Shaw E. (1951) Peritendinitis crepitians and simple tenosynovitis: a clinical study of 544 cases in industry. Br J Ind Med 1951; 8:150-160.
- Tola S., Riihimaki H., Videman T., Viikari-Juntura E., and Hanninen K. (1988). Neck and shoulder symptoms among men in machine operating, dynamic physical work and sedentary work. Scandinavian Journal of work environmental health, 14(5): 299-305.

- Viikari-Juntura E. The Occupational Ergonomics handbook 1996, chapter 45 *Occupational risk factors for shoulder disorders*, Waldemar K., Marras W.S. (Ed).
- Webster B.S., Snook S.H. The cost of compensable upper extremity cumulative trauma disorders. J Occupational Med 1994; 36:713-716.
- Wells J. A., Zipp J. F., Schuette P. T., and McEleney J. (1983). Musculoskeletal disorders among letter carriers: A comparison of weight carrying, walking and sedentary occupations, Journal of Occupational Medicine, 25(11), 814-820.
- Wells R. (1996). The Occupational Ergonomics handbook 1996, chapter 43 *Integrated analysis of upper extremity disorders*, Waldemar K., Marras W.S. (Ed).
- Wickstrom G., Pentti J., Hyytianen K., & Uutela A. (1989). Type A behaviour and back pain. Work and stress, 3(2), 203-207.
- Yarnold P. R. & Grimm L. G. (1982). Time-urgency among coronary-prone individuals. Journal of abnormal psychology, 91, 175-177.

Appendix A: Jenkins Activity Survey

Jenkins Activity Survey

The following survey asks questions about aspects of your behavior. Each person is different, so there are no "right" or "wrong" answers.

For each question, choose the answer that is true for you, and mark this response on your answer sheet.

1. Do you ever have trouble finding time to get your hair cut or styled?

A.Never
B.Occasionally
C.Almost always

2. How often does your job or school "stir you into action"?

A.Less often than most people
B.About average
C.More than most people

3. Is your everyday life filled mostly by

A. problems needing a solution?
B. challenges needing to be met?
C. a rather predictable routine of events?
D. not enough things to keep me interested or busy?

4. Some people live a calm, predictable life. Others find themselves facing unexpected changes, frequent interruptions, inconveniences, or "things going wrong." How often are you faced with these minor (or major) annoyances or frustrations?

A.Several times a day
B.About once a day
C.A few times a week
D.Once a week
E.Once a month or less

5. When you are under pressure or stress, what do you usually do?

A.Do something about it immediately
B.Plan carefully before taking any action

6. Ordinarily, how rapidly do you eat?

A.I'm usually the first one finished.
B.I eat a little faster than average.

C.I eat at about the same speed as most people.
D.I eat more slowly than most people.

7. Has your spouse or a friend ever told you that you eat too fast?

A.Yes, often
B.Yes, once or twice
C.No, never

8. How often do you find yourself doing more than one thing at a time, such as working while eating, reading while dressing, or figuring out problems while driving?

A.I do two things at once whenever practical.
B.I do this only when I'm short of time.
C.I rarely or never do more than one thing at a time.

9. When you listen to someone talking, and this person takes too long to come to the point, how often do you feel like hurrying the person along?

A.Frequently
B.Occasionally
C.Almost never

10. How often do you actually "put words in the person's mouth" in order to speed things up?

A.Frequently
B.Occasionally
C.Almost never

11. If you tell your spouse or a friend that you will meet somewhere at a definite time, how often do you arrive late?

A.Once in a while
B.Rarely
C.I am never late.

12. How often do you find yourself hurrying to get places even when there is plenty of time?

A.Frequently
B.Occasionally
C.Almost never

13. Suppose you are to meet someone at a public place (street corner, building lobby, restaurant) and the other person is already 10 minutes late. What will you do?

A.Sit and wait
B.Walk about while waiting
C.Usually carry some reading matter or writing paper so I can get something done while waiting

14. When you have to "wait in line" at a restaurant, a store, or the post office, what do you do?

A.Accept it calmly
B.Feel impatient but not show it
C.Feel so impatient that someone watching can tell I am restless
D.Refuse to wait in line, and find ways to avoid such delays

15. When you play games with young children about 10 years old (or when you did so in past years), how often do you purposely let them win?

A.Most of the time
B.Half the time
C.Only occasionally
D.Never

16. When you were younger, did most people consider you to be

A.definitely hard-driving and competitive?
B.probably hard-driving and competitive?
C.probably more relaxed and easygoing?
D.definitely more relaxed and easygoing?

17. Nowadays, do you consider yourself to be

A.definitely hard-driving and competitive?
B.probably hard-driving and competitive?
C.probably more relaxed and easygoing?
D.definitely more relaxed and easygoing?

18. Would your spouse (or closest friend) rate you as

A.definitely hard-driving and competitive?
B.probably hard-driving and competitive?
C.probably relaxed and easygoing?
D.definitely relaxed and easygoing?

19. Would your spouse (or closest friend) rate your general level of activity as

A.too slow -- should be more active?
B.about average -- busy much of the time?
C.too active -- should slow down?

20. Would people you know well agree that you take your work too seriously?

A.Definitely yes
B.Probably yes
C.Probably no
D.Definitely no

21. Would people you know well agree that you have less energy than most people?

A.Definitely yes

B.Probably yes
C.Probably no
D.Definitely no

22. Would people you know well agree that you tend to get irritated easily?

A.Definitely yes
B.Probably yes
C.Probably no
D.Definitely no

23. Would people who know you well agree that you tend to do most things in a hurry?

A.Definitely yes
B.Probably yes
C.Probably no
D.Definitely no

24. Would people who know you well agree that you enjoy a “contest” (competition) and try hard to win?

A.Definitely yes
B.Probably yes
C.Probably no
D.Definitely no

25. How was your temper when you were younger?

A.Fiery and hard to control
B.Strong but controllable
C.No problem
D.I almost never got angry

26. How is your temper nowadays?

A.Fiery and hard to control
B.Strong but controllable
C.No problem
D.I almost never get angry

27. When you are in the midst of studying or doing a job and someone (not your boss) interrupts you, how do you usually feel inside?

A.I feel O.K. because I work better after an occasional break
B.I feel only mildly annoyed.
C.I really feel irritated because most such interruptions are unnecessary.

28. How often are there deadlines on your job or in your courses (If deadlines occur irregularly, please circle the closest answer below)?

A.Daily or more often
B.Weekly

C.Monthly or less often
D.Never

29. These deadlines usually carry

A.minor pressure because of their routine nature.
B.considerable pressure, since delay would upset things a great deal
C.Deadlines never occur on my job or at school

30. Do you ever set deadlines or quotas for yourself at work, in courses, or at home?

A.No
B.Yes, but only occasionally
C.Yes, once a week or more

31. When you have to work against a deadline, what is the quality of your work?

A.Better
B.Worse
C.The same (Pressure makes no difference.)

32. At work or school, do you ever keep two jobs or projects moving forward at the same time by shifting back and forth rapidly from one to the other?

A.No, never
B.Yes, but only in emergencies
C.Yes, regularly

33. Are you content to remain at your present job level for the next five years?

A.Yes
B.No, I want to advance.
C.Definitely no; I strive to advance and would be dissatisfied if not promoted in that length of time.

34. If you had your choice, which would you rather get?

A.A small increase in pay without a promotion to a higher level job
B.A promotion to a higher job without an increase in pay

35. In the past three years, have you ever taken less than your allotted number of vacation days at work or maintained a regular study schedule during school vacations (e.g., Thanksgiving, Christmas)?

A.Yes
B.No
C.My type of job does not provide regular vacations.

36. In the past three years, how has your personal yearly income changed?

A.It has remained the same or gone down.
B.It has gone up slightly (as the result of cost-of-living increases or automatic raises based on years of service).

C.It has gone up considerably.
D.I don’t have a regular income.

37. How often do you bring your work home with you at night, or study materials related to your job or courses?

A.Rarely or never
B.Once a week or less
C.More than once a week

38. How often do you go to your place of work when you are not expected to be there (such as nights or weekends) or go to the university when class is not in session?

A.It is not possible on my job or at my school.
B.Rarely or never
C.Occasionally (less than once a week)
D.Once a week or more

39. When you find yourself getting tired on the job or while studying, what do you usually do?

A.Slow down for a while until my strength comes back
B.Keep pushing myself at the same pace in spite of tiredness

40. When you are in a group, how often do the other people look to you for leadership?

A.Rarely
B.About as often as they look to others
C.More often than they look to others

41. How often do you make yourself written lists to help you remember what needs to be done?

A.Never
B.Occasionally
C.Frequently

For questions 42-46, compare yourself with the average worker in your present occupation or student at your university. Please mark the most accurate description.

42. In amount of effort put forth, I give

A.much more effort.
B.a little more effort.
C.a little less effort.
D.much less effort.

43. In sense of responsibility, I am

A.much more responsible.
B.a little more responsible.
C.a little less responsible.
D.much less responsible.

44. I find it necessary to hurry

A.much more of the time.
B.a little more of the time.
C.a little less of the time.
D.much less of the time.

45. In being precise (careful about detail), I am

A.much more precise.
B.a little more precise.
C.a little less precise.
D.much less precise.

46. I approach life in general

A.much more seriously.
B.a little more seriously.
C.a little less seriously.
D.much less seriously.

For questions 47-49, compare your present work with your work setting of five years ago. If you have not been working for five years, compare your present job with your first job.

47. I worked more hours per week

A.at my present job.
B.five years ago.
C.Cannot decide

48. I carried more responsibility

A.at my present job.
B.five years ago.
C.Cannot decide

49. I was considered to be at a higher level (in prestige or social position)

A.at my present job.
B.five years ago.
C.Cannot decide

50. How many different job titles have you held in the last 10 years? (Be sure to count shifts in kinds of work, shifts to new employers, and shifts up and down within a firm.)

A.0-1
B.2
C.3
D.4
E.5 or more

51. How much schooling did you receive?

A.Graduated from high school
B.Trade school or business college
C.Some college (including junior college)
D.Graduated from a four-year college
E.Post-graduate work at a college or university

52. When you were in school, were you an officer of any group, such as a student council, glee club, 4-H club, sorority or fraternity, or captain of an athletic team?

A.No
B.Yes, I held one such position.
C.Yes, I held two or more such positions.

Appendix B: Informed consent form Phase I

North Carolina State University
INFORMED CONSENT FORM

Title of Study: Assessing work style during an overhead work task – Phase I

Principal investigator: Sunil Sudhakaran **Faculty Sponsor:** Dr. Gary A. Mirka

You are invited to participate in a research study. The purpose of this study is to investigate the various relationships between personality and occupational task performance. YOU MUST BE A MALE AND BETWEEN THE AGE OF 18 AND 26 YEARS OF AGE to participate in this study.

INFORMATION

This is the first phase of an overall study exploring the relationship between personality type and task performance. This session will require 20 minutes to complete. In this phase you will be asked to complete a survey asking questions about your perceptions, work habits, etc. There are no "right" or "wrong" scores on these measures. The scores are being used strictly for research purposes. They are not intended to be used for diagnostic purposes. If you are selected for phase II, the information collected in this phase of the study will be merged with the information collected in the second phase. You will be contacted for the second phase if you qualify, based on your responses to the survey.

RISKS

Your participation in this study involves minimal risk. You will be asked questions about your feelings & behaviors that you might consider to be personal and/or sensitive for the Jenkins activity survey. Please initial here: _______ if you don't have problem with disclosing some of your personal information. Disclosure of the information isn't expected to put you at risk of criminal or civil liability. Individual results will be discussed only among experimenters. Published results will be reported such that no individual's disclosure might be made public.

BENEFITS

While you will not benefit directly from this study, results of the study will increase our knowledge of how people differ from each other and how they might affect physical well being during job performance.

CONFIDENTIALITY

The information in the study records will be kept strictly confidential. Data will be stored securely and will be made available only to persons conducting the study unless you specifically give permission in writing to do otherwise. No reference will be made in oral or written reports, which could link you to the study.

COMPENSATION

No compensation Initial Here: ___________

CONTACT

If you have questions at any time about the study or the procedures, you may contact the researcher, Sunil Sudhakaran, at 339 Riddick, or call (919) 515-7210. If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact the Chair of the NCSU IRB for the Use of Human Subjects in Research Committee, Box 8101, NCSU Campus, (919-513-1837).

PARTICIPATION
Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is completed your data will be returned to you or destroyed.

CONSENT
"I have read and understand the above information. I have received a copy of this form. I agree to participate in this study."

Subject's signature_______________________________ Date _________________

Investigator's signature__________________________ Date _________________

Appendix C: Informed consent form Phase II

North Carolina State University
INFORMED CONSENT FORM

Title of Study: Assessing work style during an overhead work task- Phase II

Principal investigator: Sunil Sudhakaran **Faculty Sponsor:** Dr. Gary A. Mirka

You are invited to participate in a research study. The purpose of this study is to investigate the various relationships between personality and occupational task performance. YOU MUST BE A MALE AND BETWEEN THE AGE OF 18 AND 26 YEARS OF AGE to participate in this study.

INFORMATION

This is the second phase of an overall study exploring the relationship between personality type and task performance. This session will require approximately one hour to complete. Today you will be asked to perform some simulated occupational task. First you will be asked to do an overhead assembly task (putting a nut on a bolt). You will first be instructed on how to conduct this task and given an opportunity to familiarize yourself with the task. You will be instructed to do the task for 40 cycles and you can leave as soon as you complete the 40 cycles. You will also be asked to rate your discomfort level at regular intervals during the actual overhead task on a Visual Analogue Scale (VAS). Some basic physical measurements (e.g., height, weight, hand/arm dimensions, etc.) will also be recorded. You will be videotaped while performing the tasks.

RISKS

Your participation in this study involves minimal risk. You may experience some musculoskeletal discomfort/pain and/or soreness during or following the experiment, similar to what you might experience after doing some physical activity that is out of the ordinary for you. You may also experience some discomfort from standing for an extended period of time while performing the tasks. Please initial here: ______ if you don't have any major physical disability (motor skills) or muscular discomfort before starting the experiment.

BENEFITS

While you will not benefit directly from this study, results of the study will increase our knowledge of how people differ from each other and how they might affect physical well being during job performance.

CONFIDENTIALITY

The information in the study records will be kept strictly confidential. Data will be stored securely and will be made available only to persons conducting the study unless you specifically give permission in writing to do otherwise. No reference will be made in oral or written reports that could link you to the study.

COMPENSATION

A Free ergonomics lab T-shirts will be given after completion of the study.Initial here: ___________

CONTACT

If you have questions at any time about the study or the procedures, you may contact the researcher, Sunil Sudhakaran, at 339 Riddick, or call (919) 515-7210. If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact the Chair of the NCSU IRB for the Use of Human Subjects in Research Committee, Box 8101, NCSU Campus, (919-513-1837).

PARTICIPATION

Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is completed your data will be returned to you or destroyed.

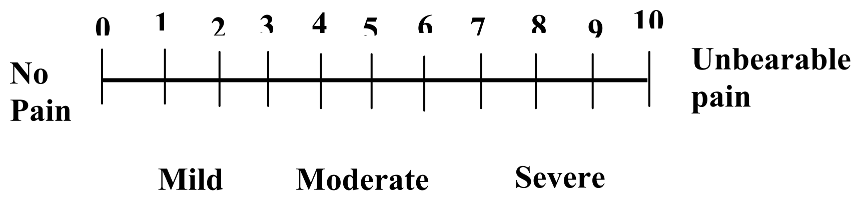
CONSENT

"I have read and understand the above information. I have received a copy of this form. I agree to participate in this study."

Subject's signature________________________________ Date _________________

Investigator's signature___________________________ Date _________________

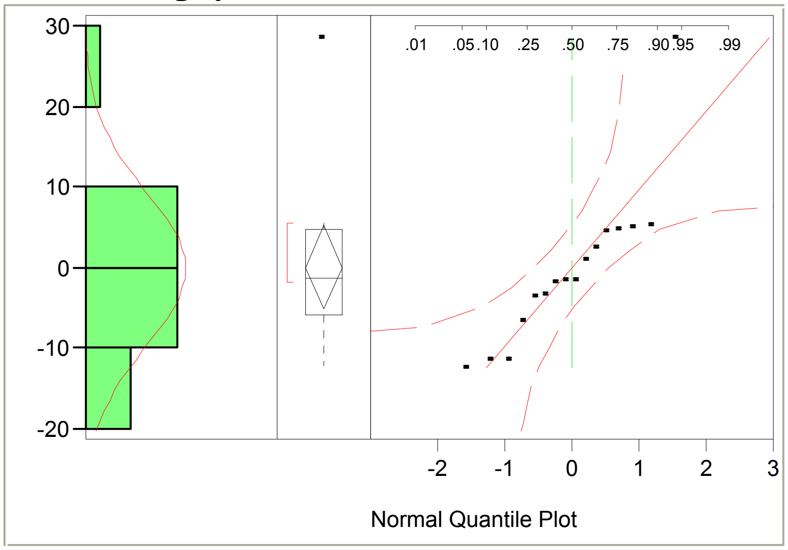
Appendix D: Visual Analogue Scale (VAS)



Visual Analog Scale (VAS)

Appendix E: Normal plots of residuals

Residual avg cycle time

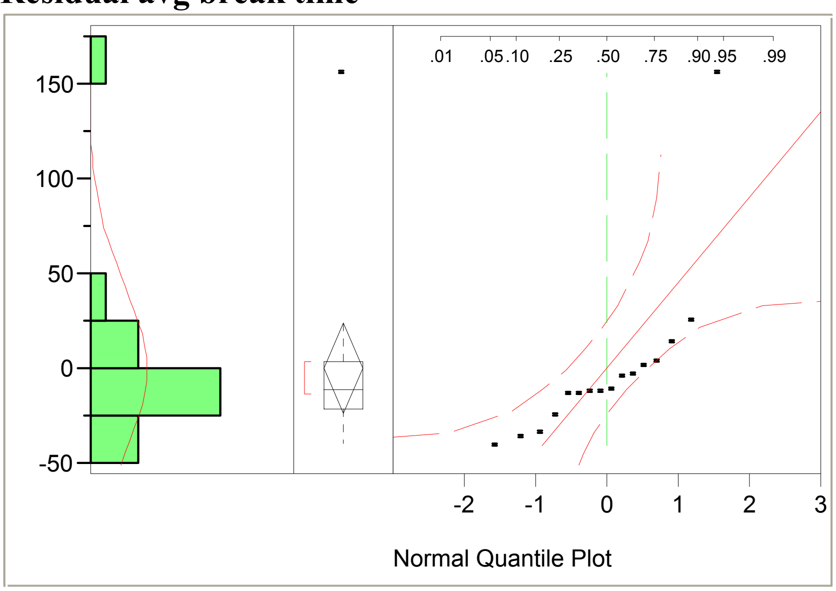


Goodness-of-Fit Test

Shapiro-Wilk W Test

W		Prob<W
0.845292		0.0110

Residual avg break time



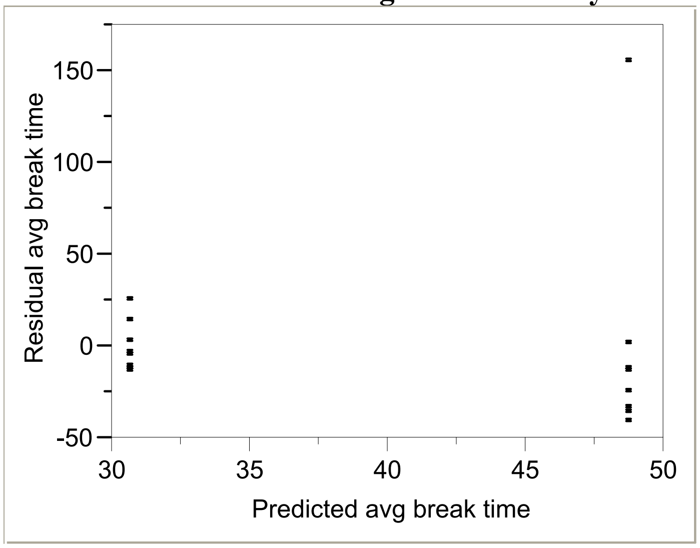
Goodness-of-Fit Test

Shapiro-Wilk W Test

W		Prob<W
0.645152		<.0001

Appendix F: Graphical assessment of homogeneity of variances

Bivariate Fit of Residual avg. break time By Predicted avg. break time



Bivariate Fit of Residual avg cycle time By Predicted avg cycle time