Chapter 3

Factors Influencing Human Postures

3.1 Introduction

Postures and motions generated by the human body are very difficult to simulate since the human body has so many interrelated muscles that produce movement. They are affected by factors such as muscular strength, fatigue, general health or state of mind. Biomechanical and biomedical studies have tried to model some of these factors [Kul84][Has71].

The force applications in the most of occupational tasks are the result of a combination of various limb poses, and are effected through patterns of muscles contractions of the limbs and trunk [Kum86]. That succession of muscles contractions are directly influenced by physiological factors such as fatigue or psychological factors such as the state of mind.

3.2 Physiological Factors

3.2.1 The Muscular and the Skeletal System

The muscular system is composed of specialized cells called muscle fibers. The main goal of the muscular system is to provide movement for the body [Bla92]. All muscles do is contract and relax. There are approximately 650 muscles in the human body.

The skeletal system is made up of the bones that hold the human body upright. It determines the shape of the body, and protects the organs.

Both the muscular system and the skeletal system work closely together to allow the human body to move.

The combined action of joints, bones and skeletal muscles produces movements such as walking and running. Muscles have other important functions in the body. These functions are posture and joint stability. Postures like sitting and standing are maintained because of muscle contraction. The skeletal muscles are continually making fine adjustments that hold the body in stationary positions. For example, the continuous postural changes produced when two standing persons are talking [Smi53].

In the human body, there are three types of muscles: skeletal, smooth, and cardiac. Skeletal muscles are connected to bones to provide movement. Smooth muscles form the walls of organs, such as the stomach. The cardiac muscles keep the heart beating.

Human body poses mainly depends on skeletal muscles actions. Skeletal muscles are attached to bones and are responsible for skeletal movements (Figure 3-1).

Skeletal muscles usually act in groups rather than individually, so that most movements are produced by the coordinated action of several muscles.

Agonist muscles are those whose contractions cause the movement. Antagonist muscles relax while the agonist contract. Also, when a weight is raised in a concentric contraction, the antagonist muscles contract eccentrically to control the movement and to provide greater joint stability.

A concentric contraction is a movement in which the muscle shortens as it contracts, done by the biceps muscle in the upward motion of biceps curl. If the direction is inverted and the weight is lowered, the biceps muscle remains contracted, but in an eccentric contraction: a movement in which the muscle lengthens during contraction.

Antagonist muscles have opposite actions and opposite locations. Synergist muscles assist the agonist and reduce undesired action or unnecessary movement.

The Peripheral Nervous System (PNS) consists of nerves that exit the Central Nervous System (CNS) to their specific location within the body according to their function. There are two types: motor nerves and sensory nerves.

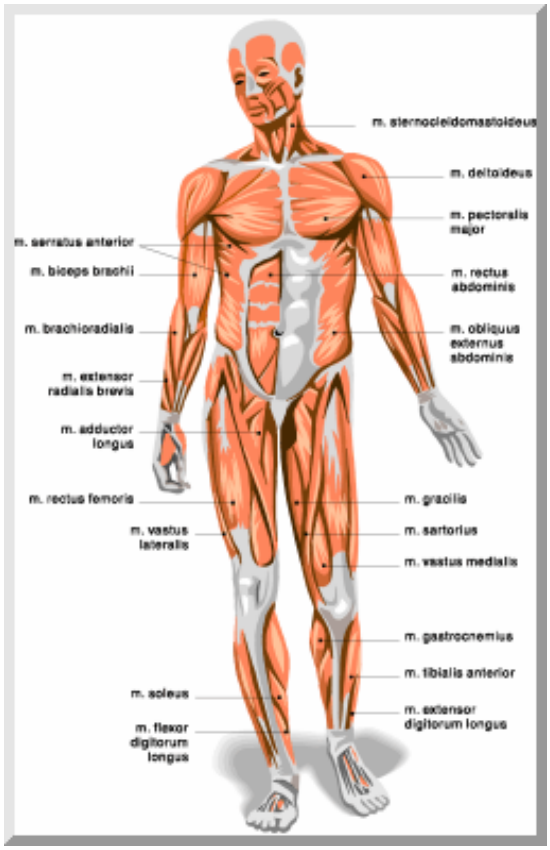

Figure 3-1. Skeletal muscles (from [Spe01])

Motor nerves control muscles and therefore locomotion. Sensory nerves are special sensory receptors in the muscles, tendons and joints that relay information concerning muscle dynamics (state of muscle stretch or contraction) and limb movements to the brain.

The peripheral portion of the central nervous system controls the skeletal muscles. Thus, these muscles are under conscious, or voluntary control.

Figure 3-2 depicts how the CNS system activates muscles. CNS processes its sensory inputs and initiates the appropriate, and coordinated, motor outputs. Muscles produce forces that in turn produce movement in the skeletal system. The physiological sensory system is affected by the force produced by the muscle and by the movement produced in the skeletal system. In fact, the physiological system gives information to the CNS that may vary the new motor outputs given to the muscles.

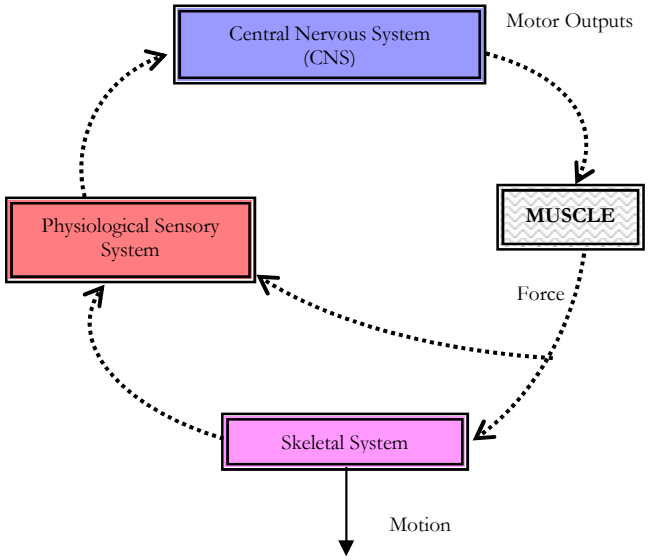

Figure 3-2. Central Nervous System (CNS) activating muscles (from [Koo01])

3.2.2 Influence of Fatigue

A study from Hashimoto defined fatigue from different points of views. Physiologists consider fatigue simply as a decrease in physical performance. Psychologists consider it as a condition affecting the mental process. Ergonomists and physicians lay stress on the consequences of fatigue [Has71].

At the neuron level, Tsaneva has described a fatigue mechanism based on two basic observations [Tsa69]. Fatigue is a biological reaction, which protects the working organ from overexertion. The protection is achieved by uncoupling the transmission of the excitation between the nerve and the working organ, i.e.. the membrane permeability is modified by the release of a substance.

Two types of muscular contractions can produce fatigue. When an activated muscle shortens, the contraction is called dynamic (isotonic). On the other case, the muscle contracts without any change in its length, then the contraction is static (isometric). Dynamic work allows muscle groups to contract and relax alternately whereas the static work induces rapid muscular fatigue [Ind94].

A fatiguing state causes the muscular strength to decrease. The purpose of several researches has been to study the effects of exhaustive muscular efforts upon strength decrements and strength recovery rate [Cla66]. They concluded that the immediate effect of fatiguing muscles is a reduction of their contractile power.

3.2.3 Age

A considerable change in postural attitudes can be observed in the elderly. It is due to the aging process. The aging process is characterized by a decrease of flexibility, strength, and power [Dan84].

The most common consequence of normal aging is the loss of skeletal muscle mass. It is due to a complex interaction of nerve and muscle alterations. Several studies have stated that many of the determinants for aerobic and anaerobic capacity change with age. In particular, muscle mass, which is central to both aerobic and anaerobic capacity, decreases with sedentary aging [Lex88] [Cog92] [Man95].

As can be seen in Figure 3-3 the loss of muscle fibers is produced in both male and females and corresponds to the age around 50 years when muscle atrophy becomes most noticeable. One of the manifestations of a decrease in muscle mass is the decreased ability to produce force.

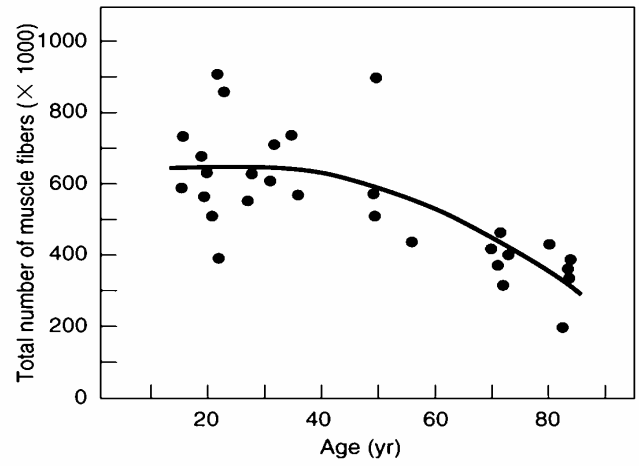

Figure 3-3. Loss of muscle fibers with age (from [Com96])

Researches that studied isometric force production characteristics during the aging process reported that the earliest decreases in strength occurred for the forearm extensors and the muscles of the lower leg around age 40, while the greatest loss of strength occurred for the two lower limb muscles (dorsiflexors and plantar flexors).

The age-related loss of muscle mass can be improved with strength training. In the study of Frontera [Fro88], subject's muscle cross sectional area increased by 11% after 12 weeks of training, which is similar to the increases experienced by young adults for similar training. The subjects in the study of Brown [Bro90] trained only one arm for twelve weeks, and increased CSA (Cross Sectional Area) in the trained arm by 17%. In all the studies, cross sectional area raised due to hypertrophy (increase in the size) of individual fibers, not by reconstruction of lost fibers.

It is clear that the manifestation of muscle fatigue in the elderly can result in mobility, postural, and gait deficiencies. To include aging in the fatigue model presented in this research, we would need to relate the decrease in muscle mass with the decrease in muscular strength (maximum voluntary contraction). Therefore, the earlier apparition of fatigue had been modeled but not the relation between fatigue and postural changes.

3.3 Psychological Factors

Neuro-psychologists study psychosocial behaviors in an effort to assess individual behavior patterns and develop diagnosis of psychological issues. In particular, a subject's emotional or mental attitudes may influence the behavior of his muscular system and, in consequence, the stances or movements adopted.

The state of mind is determinant when adopting postures, depressed people adopt different poses than happy people. Another factor that influence a person when adopting a pose is the people who surrounded him, that is, adopted poses depends on the people he has to deal with.

Figure 3-4 shows an interesting classification of muscles based on psychological muscle functions. For example, pectorals demonstrate self-worth and power, wrist flexors give fine control of social and interpersonal actions such as modifying behavior depending on the company.

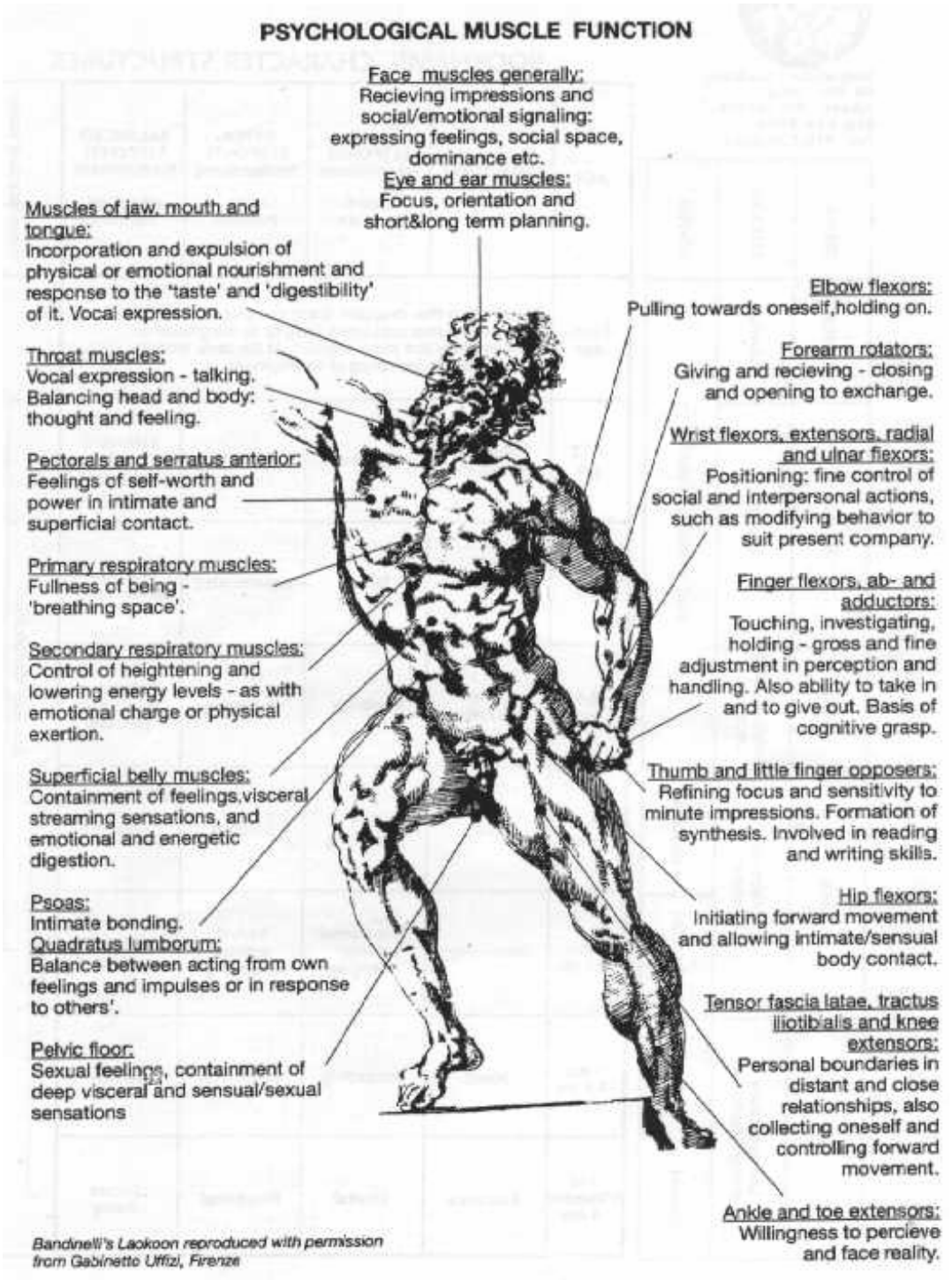

Figure 3-4. Psychological muscle function of general muscle groups (from [Bod99])

Bowen is the founder of Psycho-Physical Therapy[1]. He has studied how the body moves and how these movement patterns interact with psychological patterns [Bow03]. Psycho-Biomechanics deals with the interaction of mental, emotional and physical forces. Hence, we can affirm that psychological issues are present in the movements of the body.

3.4 Psycho-physiological Factors

3.4.1 Overview

In the previous section we introduced psychological factors that influence the behaviour of the muscular system. Now we present how a mixture between psycho and phsysiological causes can also influence postures adopted by humans.

3.4.2 Muscular Tonus

The state of mind can influence the activity of the muscular system, that is, the muscular tonus. The muscular activation, or in the contrary case, the muscular relaxation influences postures adopted by people.

A pose of muscular relaxation avoids using muscles actively. An example is the standing pose, a bored person adopts a different posture than another that is prepared to change the posture.

A very common posture is adopted when standing people rest on one leg. Standing postures are classified in two basic groups: symmetrical standing and asymmetrical standing (See Figure 3-5). In symmetrical standing, the body weight is equally distributed among both feet. In asymmetrical right pose, the body right side bears body weight while in an asymmetrical left pose, the body left side bears body weight. Asymmetrical poses are also called ”pelvic slouch” [Smi53].

Evans analyzed who uses the pelvic slouch. People just leaning with time to spare [Eva79]. In general, the pelvic slouch posture is only adopted if there is no immediate action, just remain standing. For example, people waiting to be collected, waiting for the bus or waiting for the kids to come out of school. If there is a possibility of having to do something, people adopt a symmetrical standing. In fact, the asymmetrical posture is a

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relaxed pose, incompatible with sudden responses. Therefore, standing people do not adopt that posture while doing something (police officers, waiters, etc.)

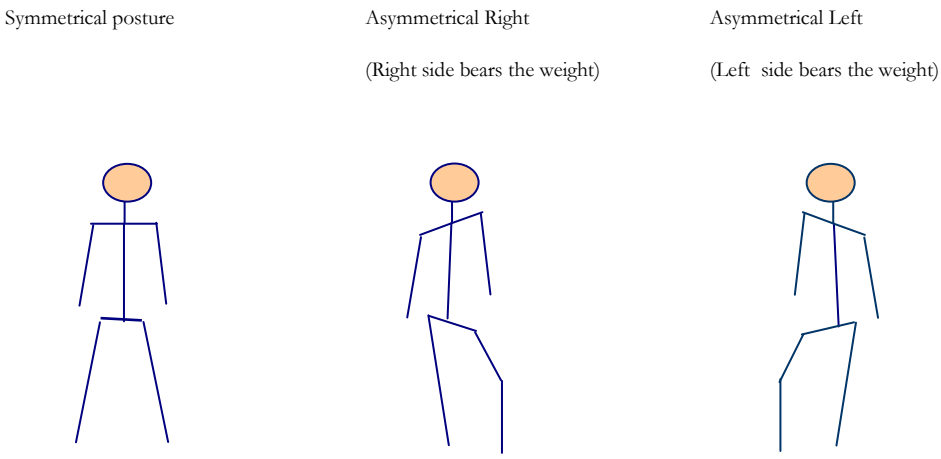

Figure 3-5. Symmetrical and Asymmetrical poses

The contraposto pose is a natural position of weight shift, where all body weight is put on one leg with the other knee bent. The contraposto posture is a typical asymmetrical pose that appeared in primitive art sculptures [Gom80]. Appendix B shows several contraposto pictures.

3.5 Training Factors

A person who is doing training to increase his muscular volume and resistance may adopt different poses and motions than those adopted before the training.

The aim of physical training is to increase body capacity. Regular training leads to favorable changes in body composition by reducing body fat and increasing muscle mass. The ultimate effect of training is the increase in muscular strength. As a principle of strength training, muscles must be exercised near peak tension for increases in strength.

In general, untrained males have greater absolute strength than untrained females. Bart Koopman in "Physiological Actuation System" gives data about strength improvement for a group of males and females. Figure 3-6 shows results for men and women after several weeks of training.

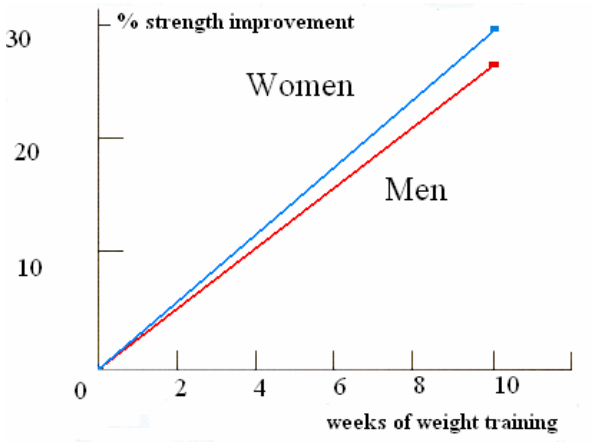

Figure 3-6. Strength improvement after weeks of training

A trained person adopts body poses and adjustments influenced by his preparation. His training influences muscular strength, fatigue apparition and others.

In this research, we are not considering people with increased strength or endurance. We deal with people with standard physical aptitudes.

3.6 Summary

In this chapter, we have reviewed the factors that influence postures and motions generated by the human body. These factors can be physiological, psychological or physical.

We have shown how motor outputs of the Central Nervous System (CNS) are directly influenced by the feedback of the Physiological Sensory System. Not only physiological variables are determinant but also psychological reasons can influence the signals sent by the CNS.

Several variables determine the global state of the human body so that it behaves differently depending on body state. In particular, our research exploits the fatigue physiological factor and the muscular tonus.