CHAPTER 1

INTRODUCTION

1.1 Background rationale

Muscle damage occurring after unaccustomed activities or high-intensity of exercise is a common physiological occurrence in daily life. Exercise-induced muscle damage (EIMD) can cause several types of muscle pathology such as muscle strain, cramp and soreness (Miles and Clarkson, 1994). Delayed onset muscle soreness (DOMS) is a common neuromuscular condition that affects individuals the day after they perform vigorous or unaccustomed exercise (O'Connor and Hurley, 2003). Some activities, such as walking down stairs, downhill running, stepping and weight training, are composed of eccentric muscle contraction which has the potential to initiate greater injury to muscles (Clarkson et al., 1992; Miles and Clarkson, 1994).

The symptoms of this kind of muscle damage usually decline within a week and might affect daily living in some degrees. Numerous people suppose that DOMS can heal by itself and does not need medical or physical interventions. However, when the symptoms of muscle damage happen in patients during a rehabilitation period, or in athletes, this may possibly interrupt the rehabilitation/training program, along with sports performance, because of neuromuscular deficits. Many researchers have examined various ideas about intervention to reduce and/ or prevent the severity of this kind of muscle damage. From a clinical perspective, preventative intervention is preferable and more important because it reduces the cost of treatment, time lost from training or rehabilitation, and the probability of persisting further injury. It also allows the continuation of exercise and competition (O'Connor and Hurley, 2003; Weerapong et al. 2004). Strenuous eccentric exercise is where contracting muscles are lengthened leading to sensations of stiffness and soreness on the next day (Clarkson et al., 1992). There are protocols of DOMS induction for lower extremity muscles using step devices to stimulate specific functional activities, and in upper extremity muscles (mostly studies in elbow flexor muscles) a variety of devices has been used to induce DOMS in this muscle group such as using dumbbells, free weights, pulley systems, or an isokinetic dynamometer. Most recent studies have used an isokinetic dynamometer device due to its advantage in the accuracy of the speed control, and the ability to adjust the resistance of the movement to avoid injury which might otherwise occur. However, there have only been a small number of studies of other muscle groups belonging to the upper extremities, such as wrist extensor muscles. This muscle group is quite important in common activities and daily living, sport activities, and is also the group of muscles that has been used as a model in clinical studies of patients with lateral epicondylagia or "tennis elbow" (Slater et al., 2003; 2005). For specific muscle study, we cannot directly imply that different muscle group behaves similarly in the nature of DOMS as previously described because it is different in proportion of muscle fiber's types, muscle shapes and functions. In this present study, we concentrated on investigating the effect of DOMS induction in wrist extensor muscles.

Six hypotheses have been proposed for the pathomechanism of DOMS, including: lactic acid, muscle spasm, connective tissue damage, muscle damage, inflammation, and the enzyme efflux theories. However, an integration of two or more of these theories has been used to explain the DOMS phenomenon (Cheung et al., 2003). Regarding to lactic acid, the evidence to date claims that it does not correlate to the symptom of DOMS as well as the inflammatory response of DOMS which remains controversial because a lack of treatment efficacy for the inflammatory drug in prevention and treatment of DOMS (Cheung et al., 2003; Weerapong et al., 2004). The recent study for DOMS prevention focuses mainly on the mechanisms of muscle spasm, connective tissue damage and muscle damage. The symptoms of DOMS include tenderness to palpation, decreased joint range of motion (ROM), decreased flexibility and decreased muscle force production. DOMS is characterized by an increasing soreness sensation 24 to 48 hours following the activity, with a peak pain level usually 24 to 72 hours after exercise (Weerapong et al., 2004; Clarkson et al., 1992). The soreness normally subsides within one week (Miles and Clarkson, 1994). ROM reduction occurs immediately after exercise and bottoms out on the second or third day after exercise (Weerapong et al., 2004; Clarkson et al., 1992; Jamurtas et al., 2005). The loss of ROM appears to return to normal within 10 days after exercise. Muscle strength reduces immediately after exercise and seems to be slower to recover than the other symptoms (Weerapong et al., 2004; Clarkson et al., 1992). For the time course of these characteristics, most research has not followed up on assessing DOMS beyond the time period of the acute healing process (i.e. 4-5 days). Supposedly, the data should be further collected until reaching the baseline of each individual subject within regular intervals. Other parameters such as edema and localized inflammatory response also happen after muscle damage such as swelling. Swelling gradually develops a few days after exercise, reaching peak values at 5 days after exercise. There does not seem to be a correlation between swelling and muscle soreness, because the time courses of symptoms are different (Clarkson et al., 1992;

Nosaka and Sakamoto, 2001). In addition, some studies show that muscle damage indicators, such as plasma creatine kinase (CK) levels, peaked on the fourth day after exercise and took several days to return to their normal level (Clarkson et al., 1992; Zainuddin et al., 2005). Although, CK has been used primarily as an indicator of muscle damage, there is no direct relationship between CK and any other parameters indicating muscle damage because of the large inter-subject variability. A feeling of tenderness, which is the main symptom of DOMS, is evoked by muscle palpation, contraction and stretch. In the damaged region, there is a lower pain threshold caused by hypersensitivity to stimuli (hyperalgesia) (Weerakkody et al., 2001; 2003). Hyperalgesia is characterized by a decrease in the threshold for eliciting pain, which is divided into two forms; primary and secondary hyperalgesia. The primary hyperalgesia is a response to both mechanical and thermal stimuli whereas the secondary hyperalgesia is a response to mechanical stimuli only (Wright et al., 1992). DOMS has been examined in response to the mechanically induced pain threshold (i.e., pressure pain threshold (PPT)). PPT is an effective index in measuring the extent of muscle tenderness (Slater et al., 2003; 2005, Nie et al., 2005). As far as, there has been no study using thermal stimuli to evaluate DOMS. Thus in this study, we included thermal pain threshold to evaluate the form of hyperalgesia in DOMS. This provided further understanding the pathophysiology of DOMS precisely. There is some evidence that suggests there is a role for large fiber mechanoreceptors in DOMS. Muscle mechanoreceptors, including muscle spindle, play a role in generating DOMS and can be stimulated by vibration (Weerakkody et al., 2001; 2003). This study used vibration as a stimulus to examine tissue damaged sensitivity. Muscle receptors appear to be involved in two different roles which are automatic (unconscious) control and conscious sensation. Conscious sensation, specifically, kinaesthesia, or position sense is a major role of muscle receptors (Allen and Proske, 2006). Some studies have investigated position sense after muscle fatigue and damage after exercise. The studies have shown that eccentric exercise leads to a disturbance of muscle receptors with a declined response in position sense and reduced muscle force (Brockett et al., 1997; Walsh et al., 2004). The most recent study suggests that this kind of sensitivity could be associated with the symptom of DOMS. DOMS is mostly described in local structure but it may be caused by upper motor neuron activity, such as central fatigue. Recent studies have also shown that central neuron involvement causes slower reaction times and delay the speed of upper-limb movement in the chronic lateral epicondylalgia group (Bisset et al., 2006). Muscle or connective tissue damage may lead to changes in recruitment patterns or changes in the temporal sequencing of muscle activation patterns caused by the presence of muscle dysfunction (Cheung et al., 2003). Central sensitivity changes caused by DOMS may explain the increase in referred pain frequency and enlarged pain areas (Allen and Proske, 2006), and muscle soreness might facilitate the central components of temporal summation to mechanical stimulation (Nie et al. 2006). As describe, the impact of DOMS on motor performance has not been well researched, specifically reaction time. In practical setting, the reaction time is quite difficult to determine selectively. Most studies use the response time (reaction time plus movement time) to represent the reaction time (Bisset et al., 2006). Only a few studies have focused on motor performance in specific pathologic conditions or disorders. The motor performance of the arm in DOMS has not been studied before.

Some useful methods to prevent musculoskeletal injuries are traditional interventions such as therapeutic exercise, physical modalities, and massage. Theoretically, using such therapeutic approaches, it may be possible to prevent DOMS. In clinical practice, for example, we usually do stretching before the exercise as a preventative of muscle damage. Stretching can reduce the tension on the muscle-tendon unit that affects the visco-elastic component of tissue leading to an increase in the compliance of muscle and a reduction in muscle stiffness; consequently less force could be produced in the muscle during a specified stretch. The resulting improvement of muscular flexibility possibly reduces muscle and connective tissue damage (Cheung et al., 2003; Weldon and Hill, 2003). However, previous studies have not proved the effectiveness of static stretching on the prevention of DOMS (High et al., 1989; Rodenburg et al., 1994). Proprioceptive neuromuscular facilitation (PNF) is one of the most effective stretching techniques which have been proved to increase muscle flexibility (Sady et al., 1982; Spernoga et al., 2001). PNF technique has not yet been evaluated in DOMS, it might have some potential effect on DOMS. Warm up of muscle is routinely recommended as an approach to prevent injury. Warm up techniques can be broadly classified into active (exercise) and passive warm up (heat application) (Bisop, 2003). Warm-up or heat application aim to elevate muscle temperature, increase muscle blood flow, and increase neurological excitability before starting exercise may also influence the level of muscle damage, and muscle-tendon extensibility (Weerapong et al., 2004). Thus, this thesis study evaluated the effect of general passive warm up by using sauna and local passive warm up by using hot pack, which are practical techniques that have not been evaluated in DOMS prevention. In addition, massage is a possible preventative strategy for DOMS, as it can increase muscle blood flow, muscle temperature, muscle flexibility, and reduce tissue adhesion that could reduce injury risk factors (Weerapong et al., 2004). There has been much research into the effectiveness of massage on DOMS treatments, but the use of massage before exercise to prevent DOMS has not been examined. As in the rationale, there is little scientific evidence to support these assertions and little hypothetical foundation for recommending the success of the physical therapy applications on DOMS prevention. It is interesting to examine the efficacy of these preventative interventions on DOMS.

Since, the nature of DOMS is still not clearly understood and thus the aim of this study is also to investigate the characteristics of DOMS following the exercise induction. The proposed investigation requires more work on understanding DOMS in wrist extensors, with the aim of identifying the variety of sensori-motor functions (i.e., maximum force, response time, mechanical and thermal pain, ROM, vibration & position senses) before the preventative study. These studies would be useful for understanding the characteristic of DOMS, and then continue to the study of identifying prevention strategies for DOMS after the parameters of DOMS are precisely recognized.

1.2 Aims and objectives of this thesis

1.2.1 Overall aims

This thesis undertook an investigation of delayed onset muscle soreness (DOMS) characteristics in the wrist extensor muscle on sensori-motor parameters and its prevention.

1.2.2 Specific objectives

1. Study the reliability of outcome measurements
2. Study the characteristics of DOMS (pain intensity, thermal and mechanical pain thresholds, vibration senses, joint position error, ROM, response time, muscle strength) from day 1 to 14 or until return to the baseline.
3. Determine the effect of PNF technique on DOMS
4. Determine the effect of massage on DOMS
5. Determine the effect of hot pack on DOMS
6. Determine the effect of sauna on DOMS

1.3 Outline of the thesis

Apart from the introduction (chapter 1), this thesis is comprised of another 5 chapters. Chapters 2 review the literature regarding the characteristics of DOMS and possible achievement of physical interventions for the prevention of DOMS. Chapter 3 describes the overall methodology and experimental procedure of the studies in this thesis. Chapter 4 shows the results of the reliability study, the study of DOMS characteristics and the study of DOMS preventions. Chapter 5 is the discussion part for the main studies including DOMS characteristics and its prevention. Finally, an overall summary of the findings of this thesis are presented in the chapter 6.