CHAPTER I

INTRODUCTION

1. Rationale

High force production develops during the activity when muscle actively lengthens. This phenomenon is known as eccentric contraction and has neural, contractile (muscular) and non-contractile components (connective tissue) (1). The connective tissues refers to parallel elastic component such as the sarcolemma, epimysium, perimysium and endomysium and a series elastic component such as the tendon (2). With exercise or training, it is well-known that neural adaptations demonstrate by changes in electromyographic (EMG) activities (3), muscular adaptations reveal an increase in the muscle size (4, 5), the pennation angle and the muscle fiber length (6, 7). On the other hand, the connective tissue adaptation has not been documented.

Achilles tendinopathy is an overuse injury that is common in athletes, but is also seen in the sedentary people. The prevalence of Achilles tendinopathy in athletes, especially in runners has been estimated between 11% and 24% (8, 9). Eccentric training of calf muscles has been effective treatment in Achilles tendinopathy, but the mechanism unknown (10-12). Although limited information regarding to the tendon adaptation following the eccentric training is noted, it has been widely used in clinical situation because it shows good clinical results i.e. a decrease in pain and improve the time to return to previous physical activity level e.g. in patients with Achilles tendinosis (10, 11, 13). In addition, changes in their tendon structures have been observed. After 12 weeks of eccentric training, a decrease in tendon thickness measured with grey scale ultrasonongraphy similar to the normal tendon size has been reported (from 8.8 ± 3.0 mm to 7.6 ± 2.3 mm) (14). In addition, investigations using microdialysis technique indicated an increase in the collagen type I synthesis in patients with Achilles tendinopathy after 12 weeks of eccentric training, but no such increase in the healthy participants (15). These clinical evidences are based on the research that pointed out that eccentric training might induce changes in the connective tissue properties (14, 15).

There is still controversy regarding to tendon adaptation following eccentric training in normal participants. Duclay et al. (16) investigated stiffness in Achilles tendon before and after 7 weeks of eccentric exercise using isokinetic dynamometer and reported an increase in tendon stiffness. In contrast, Mahieu et al. (17) did not find any change in tendon stiffness after 6 weeks of eccentric exercise using participants' body weights as the load (heel drop program). Both studies used the same ultrasonography imaging methodology, used a constant value (50 mm) of moment arm length for calculating tendon force, and using maximal voluntary contraction above 50% for calculating tendon stiffness. Therefore, the different results could be only explained by the variations in the exercise protocol. As the resistance is adjusted according to the participants' ability in the isokinetic dynamometer, the machine would provide more resistance depending on the ability of participants after 6-week training period. Therefore, our study was designed using the 6 weeks of heel drop program but the load was progressively increased depending on the exercise volume (load and the repetition). In addition, the limitations of previous studies indicate that the constant moment arm length assumption may induce an error in calculating the tendon force. Therefore, to minimize the error, measuring individual participants' tendon moment arm length using MRI was indicated. The aim of present study was to investigate the effect of eccentric training on Achilles tendon stiffness measured by ultrasonography and magnetic resonance imaging. It was hypothesized that Achilles tendon stiffness would increase after 6 week of eccentric muscle training.

2. Operational definition

2.1 Achilles tendon force is the muscle force generated pull the tendon proximally and cause a longitudinal deformation. Achilles tendon force was calculated by dividing the plantar flexor moment by the tendon moment arm length.

2.2 Tendon displacement is a distance of myotendinous junction of medial gastrocnemius was measured during muscle contraction and was assumed to represent the displacement of the Achilles tendon.

2.3 Tendon force – displacement curve is a plot (a graph) that quantifies the relationship between the load applied (newtons: N) to a structure and the deformation produced (millimeter: mm).

2.5 Tendon stiffness is the slope of load – deformation curve. This slope means the mechanical behavior of a tendon structure ($\frac{N}{mm}$).

2.6 Achilles tendinopathy is an overuse injury that is clinically characterized by a painful tendon, swelling with local tenderness and pathologic changes with sonographic feature such as hypoechogenic texture and diameter enlargement at or around the Achilles tendon.

2.7 Viscoelasticity is a behavior of material that combination of viscosity and elasticity. The viscoelastic material demonstrates viscous behavior as it responds to the rate of loading and demonstrates elasticity as it tends to return to its original size and shape.

3. Purpose of study and hypothesis

Purpose:

The purpose of this study was to investigate the change in tendon mechanical properties (tendon stiffness) of Achilles tendon following 6 weeks of eccentric training of healthy persons.

4. Hypothesis:

The eccentric training protocol would increase tendon stiffness of Achilles tendon of healthy persons.

5. Application advantages

The benefits from this present study may provide important information regarding to eccentric training on tendon mechanical properties. The knowledge could be used as a research document to confirm an effective program in the rehabilitation in patients with Achilles tendinopathy and prevent tendon injuries in athletes.