CHAPTER III

MATERIAL AND METHODS

3.0 Introduction

As comprehensively discussed in chapter II, previous investigations has initially rejected the idea of utilizing elastic resistance in athletic setting, because the magnitude of external force in ER has shown to be less than that requiring maximal activation (Hopkins *et al.,* 1999; Hostler *et al.,* 2001). In other words, the application of ER has been constrained in rehabilitational purposes based on this ideology that "elastic device provides low level of external force" (Ebben and Jensen, 2002; Hodges, 2006; Newsam *et al.,* 2005; Treiber *et al.,* 1998). On the other hand, there are few evidences that indicated no significant difference in EMG activity level between muscles exercised by elastic resistance and conventional exercise devices such as dumbbell (Lim and Chow, 1998; Matheson *et al.,* 2001; Muhitch, 2006). However, neither of these studies could be addressed to make a judgment on efficiency of elastic device in developing strength in healthy individuals, particularly athletes; because, these studies have been concerned over rehabilitation purposes and consequently low-resistance elastic bands were employed on them.

Accordingly, two strategies were employed to increase resistance of the elastic device. Firstly, additional elastic bands were used in parallel to the current elastic device to improve the tensile force throughout the entire ROM (Hodges, 2006; Simoneau *et al.,* 2001). Secondly, the resting length of the elastic material was reduced to increase the provided elastic force particularly at the beginning of lifting phase (Page and Ellenbecker, 2003). In series of three studies we investigated if enhancing the tensile force of elastic device, via changing the resting length and number of elastic bands in parallel, could result in achieving similar neuromuscular and hormonal responses as conventional resistance exercises in healthy subjects.

In the first research electromyographic activity (EMG) and Resultant Muscle Torque (RMT) pattern were quantified and compare between ER and Dumbbell (DB) within performing 8 RM biceps curl exercise. In the second investigation, similar methodology was used as the first study however this time the pattern of EMG activity and torque production was quantified and compared between ER and NM within performing 8 RM seated knee extension exercise.

The data observed in the second study were the cornerstone of conducting the third investigation. In this study, knee extensor muscles exhibited equal overall EMG activity during performing 8RM elastic resistance exercise (E30) compared with NM, despite that significantly less external force was employed during E30 than NM (for more details see section 5.3). Encouraged by these data, the third study was conducted to investigate if equal level of muscle activation would result in equal neuromuscular and anabolic hormonal responses between the two modes of training. The measurement schemes of the three experiments are presented in this chapter. Details could be seen in the 4th, 5th and the 6th chapters.

3.1 Measurement scheme of the 1st and 2nd studies

The experimental procedures of the first and second studies were closely similar. The sources of discrimination between the two studies were the modes of training and muscle groups. In these two investigations, subjects completed a series of 8 RM biceps curl (1st study) and seated knee extension (2nd study) by three modalities of resistance exercises comprising:

(iv) DB (1st study) / or NM (2nd study)

(v) Elastic tubing with initial length (E0)

(vi) Elastic tubing with 30% decrement of initial elongation (E30).

The level of muscle activation as well as kinetic and kinematic values such as external force, acceleration and range of motion were collected and synchronized by data acquisition package Myoresearch-XP (Noraxon**,** Scottsdale, USA, Master Edition). Data were collected from all repetitions of 8 RM while the first (initial), the 5th (middle) and the 8th (last) repetitions were selected for further analysis. Appointed repetitions were partitioned into concentric and eccentric phases based on the end points determined, by the electrogoniometer traces. Then, each phase was further divided into 3 equal segments (totally 6 phases = 3 concentric and 3 eccentric). The Root Mean Square (RMS) of rectified EMG signals and the average of external force (N) were calculated for each segment.

3.2 Measurement scheme of the 3rd study.

The experimental protocol for the third study consisted of a counterbalance cross-over design where all subjects completed two modalities of exercise with a three week "wash-out" period between experiments (Figure 3.1). The participants undertook five sets of 10 RM using ER and/or NM exercises. Average external force and EMG activity were measured and blood samples were obtained before, immediately post (IP), 15min, 30min, and 60min after termination of either the 10 RM (ER) or 10 RM (NM) exercise testing session.

Figure 3.1. The experimental design of the third study. ↑ = preliminary testing session; ↓ = performance test (MVC, submaximal isometric) + EMG, blood sampling for T, GH and LC before, immediately post, 15, 30, and 60 min following the dynamic sets ; ↕ = one set of 10RM knee extension + EMG.

In all the three studies no equalization of external force was performed among the three modes of training. Instead, subjects completed 8 RM biceps curl or seated knee extension by each of the three exercise modes (DB (or NM), E0 and E30). The rationale for selecting this method was based on the fact that:

(i) Scientific evidences has not reach to a consensus method for equalizing the magnitude of external force between ER and modes of conventional exercises

(ii) The repetitions maximum strategy is known as a popular method for prescribing high resistance training protocols. A further consideration was that undertaking 8 RM was believed to make the research outcomes more applicable to athletic conditioning.

3.3 Instrumentation

3.3.1 EMG. Muscle activity values were collected with a sample rate of 1000 Hz using a 16 bit acquisition mode with an eight channel TeleMyo™ 2400T G2 (Noraxon**,** Scottsdale, Arizona, USA) EMG system. Pre-gelled silver/silver chloride adhesive disk surface electrodes (Meditrace, Canada) were used to detect electromyographic signals. All EMG signals were passed through preamplifier leads with Input impedance > 100 MOhm and high-pass filters set to 10 Hz +/- 10% cutoff to an amplifier (gain=500) to a frequency-modulation transmitter. A PC-Interface receiver (Noraxon, Scottsdale, Arizona, USA) which could receive WiFi based telemetry data was used to forward the data from transmitter to a hard disk via USB. We collected the EMG data with data acquisition package Myoresearch-XP, Master Edition (Noraxon, Scottsdale, Arizona, USA).

Figure 3.2 TeleMyo™ 2400T G2 EMG System

3.3.2 Electrogoniometer. A 2D electrogoniometer (Noraxon, Scottsdale, Arizona, USA) with flexible axis sensor which is developed by Biometrics LTD UK were used. This electrogoniometer with Nominal Output Range +/- 180 degrees consisted of two plastic arm extended from potentiometer. The electrogoniometer was located over the subject`s lateral side of the dominant elbow and knee with it`s two axis in line with upper and lower limb of the corresponding joints. Paper Adhesive tape fixed the electrogoniometer in place. Electrogoniometer data were collected simultaneously with the same EMG system (TeleMyo™ 2400T G2).

Figure 3.3 Two-D Electrogoniometer

3.3.3 Load Cell. A Linear Force Measurement Load Cell (Noraxon**,** Scottsdale, Arizona, USA) with +/- 500 lb-F input force range (+/- 2224 N), -5 volts to +5 volts output signal range and sensitivity for 100 lb sensor 50mV / lb-F (11.35 mV/ N) were located in series with elastic band and nautilus machine cable to measure external moment of force. Calibration of the load cell occurred before collecting data began. Standard weights in 2.5-kg, 5-kg, and 10-kg held in series on the load cell. The data from the load cell were collected simultaneously with the same EMG system (TeleMyo™ 2400T G2).

Figure 3.4 Linear Force Measurement Load Cell

3.3.4 Accelerometer. A two dimension accelerometer (Noraxon**,** Scottsdale, Arizona, USA) with 400 mV/G sensitivity and 5 - 2000 Hz freq response were places at the back of the hand and lateral side of the shank. Adhesive tape fixed the accelerometer in place. The data from the accelerometer were collected simultaneously with the same EMG system (TeleMyo™ 2400T G2) on two direction of X and Y. Before testing, all sensors were calibrated based on the recommended instruction by manufacture.

Figure 3.5 Two Dimension Accelerometer

3.3.5 Elastic Tubing. Various color code of Thera-Band elastic tubing (Hygienic Corporation, Akron, OH) were used to provide elastic resistance. The original length of elastic tubing in biceps curl exercise depended on the distance from axis of the elastic tubing, which was anchored to the ground, and the bottom extremity of the load cell which it`s top extremity was connected to a handle of elastic device. This distance was measured when the subject was standing straight up on the platform, the body kept completely in anatomical position, the upper arm was in touch with the trunk and forearm and hand of subject were positioned on the 20º of elbow flexion which is the beginning of concentric phase. For leg extension, the original length of elastic tubing was measured from axis of the elastic tubing which was the basement of the nautilus machine underneath the seat and (where elastic tubing was anchored to it) and the back extremity of the load cell which it`s front extremity was connected to a custom made leather shin pat of elastic device.

Figure 3.6 Thera-Band Elastic Tubing

3.3.6 Nautilus Knee Extension Machine. This machine is specifically designed for training of quadriceps muscle group. The profile of the cam-pulley in this machine is designed to provide accommodating external force based on force generating capability of the knee extensor muscles. The seat of the machine is adjustable to maintain the axis of rotations in knee aligned with the axis of rotation of lever arm in NM. Reclined seat back angle prevents quadriceps from interfering with full range hamstring contraction. The machine provides up to 200 lb weight via weight stacks.

Figure 3.7 Nautilus Machine Leg Extension

3.3.7 Dumbbells*:* Adjustable standard dumbbell (Bowflex SelectTech) was used for this study. The dumbbell includes a central handle which could be selectively connected to one or more outer weights. The outer weights provide weight settings 2.5, 5, 7.5, 10 lbs.

Figure 3.8 Adjustable Standard Dumbbell