Chapter VII

Conclusion and Summary

Despite considerable investigations on various areas of resistance training, the influence and application of ER in healthy and trained individuals have largely ignored. Previous studies in clinical setting validated the use of ER as a cost-effective mode of training in i) reducing pain and disability, ii) impairment of strength and balance and iii) improving of function among several different populations. Patients and untrained older adults demonstrated muscle strength development 3% to 27% following resistance training with moderate ER (Mikesky *et al.,* 1994; Willett *et al.,* 1998). In addition, numerous research investigations approved the capability of ER exercise in creating adequate muscle activation in prime movers following trauma or joint injury or surgery (Hintermeister *et al.,* 1998; R. A. Hintermeister *et al.,* 1998; Hopkins *et al.,* 1999; Matheson *et al.,* 2001; Schulthies *et al.,* 1998). However, the finding of these studies cannot be interpreted and applied for strength development in athletic setting because of using low to moderate external resistance.

Among few research studies that made an attempt to examine the influence of ER in healthy population, controversial evidences have been found. In one hand, there are scientist that initially rejected the idea of using ER for developing strength in healthy individuals (they believe the magnitude of tensile force in ER material is not enough to compel prime movers to maximal force generating capability (Hintermeister *et al.,* 1998; Hostler *et al.,* 2001). On the other hand, there are some 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). The proponents of ER exercises believe that an ER device could be a suitable alternative to the use of conventional resistance training equipments, if a similar external force is provided by the ER device.

On this basis, the three studies were conducted to elucidate some of the critical features associated with using elastic device as a form of resistance in high intensity exercise programs. These studies were an attempt to investigate if improving the tensile force of elastic device, via changing the resting length and number of elastic bands in parallel, could result in achieving similar muscle activation and ultimately similar neuromuscular and hormonal responses as conventional resistance exercises in healthy subjects.

The data in the first study indicated that contrary to the rehabilitational research findings about ER, E30 could provide 14.89% higher overall muscle activation (EMG) and 17.71% higher muscle torque production (RMT) compared with DB during performing elbow flexion exercise. In addition, comparing the pattern of EMG activity and RMT between E30 and DB indicated superiority of E30 in producing considerably higher muscle activation and torque production in mid-concentric and mid-eccentric as well as late concentric and early eccentric phases of motion (2nd, 3rd, 4th and 5th segments). These data disclose the importance of reducing the initial length as well as adding elastic bands in parallel as essential strategies to develop muscle activation and torque production when using an ER device.

In second study, equal total muscle activation was observed for E30 compared with NM during performing 8 RM knee extension exercise. The equal EMG activity was also seen in mid-concentric and mid-eccentric as well as late concentric and early eccentric phases of motion (2nd, 3rd, 4th and 5th segments). However, the unique of the results in this study was that equal total average EMG between E30 and NM was observed while considerably less external load (33.46%) was employed by E30 than NM. As comprehensively discussed in chapter V, this result was attributed to requiring more control over the movement within performing ER exercise. In fact, it was speculated that since distal extremity of the lower leg (ankle) had higher degree of freedom during knee extension by ER device (compared with restricted-unidirectional NM lever arm) probably more muscle activation was required to keep the lower leg motion aligned on the sagittal plane (McCaw and Friday, 1994; Richards and Dawson, 2009). Nonetheless, these results propounded the question that "whether this was equal muscle activation between E30 and NM which could result in similar neuromuscular and hormonal responses or this was the higher applied force and torque production in NM that would make significantly greater physiological responses." On the basis of this question, the third study was concentrated on quantify and comparing the acute neuromuscular and anabolic hormonal responses following training protocols using ER and NM.

The results in the third study supported the disproportionate relationship between rate of muscle activation and magnitude of force undertaken observed in the second research. The data demonstrated that despite implementing similar exercise intensity (10-RM) and observing equal EMG activity between NM and ER, a significantly greater load (26.31%) was employed during NM compared with ER. This result reinforce the possible role of more freedom of ankle during knee extension exercise by ER device which required relatively greater muscle activation to keep lower leg motion aligned in the sagittal plane. This proposition is in line with the findings of Richards and Dawson, (2009) who observed a significant alteration in rate of motor unit recruitment due to performing exercises in a multiaxial direction. In addition, observing equal neuromuscular and hormonal responses following the two modes of training corroborated this school of thought that greater adaptive responses could be expected following exercises with multiaxial loading patterns

(Kumar *et al.,* 2002; Richards and Dawson, 2009). This speculation is in line with previous studies that proposed the possibility of an alternative signaling pathway which could be responsible for achieving higher muscle adaptation (Durand *et al.,* 2003). Overall, based on the observation of similar acute neuromuscular and hormonal responses between ER and NM, it can be anticipated that similar longer term training adaptations (muscle strength and muscle hypertrophy) will result from employing either training device. However, an unusual finding regarding the ER device compared with the NM was that less force was required to elicit and exercise intensity of 10RM. This observation requires further research to determine the underlying mechanism(s) contributing to this apparent difference between the ER and NM devices. Notwithstanding the need for further research we consider the two devices to be capable of eliciting similar training adaptations. Thus, the ER device could be a safe and affordable mode of training for regeneration of muscle strength in athletes and recreational lifters.

Future research

The data in the present study suggest elastic training (modified in terms of its resistance via applying the two aforementioned strategies) is a viable mode of resistance exercise that can provide a training stimulus that is significantly greater than that employed in rehabilitation settings. In this regard the ER device is a viable option to the NM. However, in order to have better a understanding of the impacts of maximal absolute elastic tubing exercises and better inspection into it`s application for fitness and athletes setting, more researches are required to dissect the long term neuromuscular, hormonal and hypertrophic adaptation following this exercises. In fact, the results of the present study point to the need for further research on the effectiveness of the ER device in developing muscle strength and hypertrophy. To best of our knowledge, No study to date has attempted to quantify and compare the amount of variation in size and strength gain after a controlled progressive resistance training program in contribution of elastic resistance, free weight and nautilus machine exercises, especially using sensitive technique such as MRI.