KINETIC AND EMG ANALYSIS OF THE NEW DEDIGN STEPWISE LOADING SYSTEM

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The great muscle strength and power are important factors for successful sport performance. Many strength coaches instructed their athletes to move the weight for developing muscle strength. However, most weight training systems consist of lifting a steady load, this having the drawback of not accounting for the change in strength with the change in muscle length. In order to solve this problem, this study developed a stepwise weight training system using linkage which is capable of increasing the load in isotonic contraction, then compared kinetics and muscle activation between the stepwise contraction and the traditional isotonic contraction. The results showed that both the normalized peak tension and the angle of peak tension of the stepwise contraction were significantly larger than traditional isotonic contraction. The normalized impulse and the integrated EMG of the stepwise contraction was more than traditional isotonic contraction but not reached the significance. The findings suggest that stepwise loading system can provide greater stimulus to muscle training effect than traditional weight training systems.

KEY WORDS: stepwise, EMG, strength training, elbow angle, elbow.

INTRODUCTION: Strength, one part of well fitness, is the important components for athletes to win competitions, and as we know, resistant training is the best approach to improve strength and power. Strength can be expressed either statically (isometric contraction) or dynamically (isotonic, isokinetic contraction, or variable resistance contraction), and muscle contractions can either be concentric (shortening) or eccentric (lengthening). Isotonic contraction weight training machine is a common apparatus of developing muscle strength in a fitness club. However, the rationale for gaining strength by performing conventional isotonic weight training could also be questioned. The muscle torque of most joints varied over the range of motion depending on where the muscle was attached to the skeleton relative to the joint (Hortobagyi & Katch 1990, Berg, Blanke, & Miller 1988, Pawlowski, Perrin 1989). The isotonic weight training cannot provide maximum loading in all range of motion. Furthermore, a professional weight-training device fitted the biomechanics of joint usually cost a lot. Therefore, the purposes of this study was attempt to transform conventional isotonic weight training apparatus into a stepwise weight training apparatus which is more suitable for the relationship of joint angle and torque, and then to compare kinetics and muscle activation between the stepwise contraction (SC) and the traditional isotonic contraction (TIC). This study could provide more information about reforming a better weight-training device in an economical way to increase strength more effectively for keeping fitness or wining a sport competition.

METHODS: There were two experimental phases in this study. The first experimental phase involved the design of SC for the conventional upper extremity isotonic training machine, and the second phase tried to compare the effects of kinetic and muscle activation between the SC and the isotonic contraction.

To develop the apparatus of the stepwise loading which are capable of continual increasing loads during concentric contraction. The main procedure of designing a stepwise isotonic training apparatus was to modify the loads control device of a traditional upper extremity weight training machine (BODY SOLID Co.). Every piece of iron of the upper extremity weight-training machine weights 5 kg. The procedure of modify the loads control device was attaching a 6cm rope between 2 irons. 1 When athlete lifted up the loads, the irons would be pulled up one by one. The diagram and actual of stepwise weight training apparatus was shown in Figure 1.

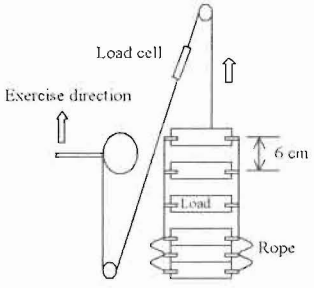
Twelve healthy males volunteered to take part in the study. The subjects were weight-lifting athletes, and none of the subject reported use of any anabolic drugs. The subjects' mean (±SD) ages, height, and weight were 19.8 ± 0.9 years, 169.2 ± 5.3 cm, and 81.4 ± 17.9 kg, respectively. The subjects were properly seated on a comfortable chair of the training machine

with upper arm supported by platform (showing in figure 2). Firstly they pulled the bar with fixed elbow at 120 degree, using maximal voluntary contraction (MVC) for 5 seconds for normalizing the EMG. And then, the subjects were randomly asked to use two kinds of weight-training apparatus to perform five cycles at 75% MVC repeatedly with slow motion, referred to less 15 degree per second. Using surface electromyography (EMG) on Biceps brachii detected the muscle activity during contraction with two different sets, moreover, the elbow angle and flexion force were simultaneously monitored by goniometer and load cell. All data was taken by the Biopac MP 150 System.

The raw EMG signal was converted to the integrated EMG (IEMG) and normalized by the IEMG during MVC. The normalized peak tension was defined as the peak force divided by MVC, as well as the angle of peak tension was set the elbow angle while exerted the peak tension during the cycle of contraction. The normalized impulse was appointed to integrating force during one cycle of arm-curl and then normalizing by the impulse during MVC.

Statistical analysis for each of parameters was using a pair t-test to compare the different effects between the SC and the TIC. The significant level was at 0.05.

Figure 1: The stepwise weight training apparatus.



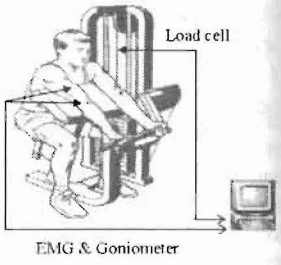


Figure 2: Experimental Set up.

RESULT AND DISCUSSION: The typical signals of the tension, elbow angle as well as the EMG of biceps by the SC were illustrated in Figure 3. And the Figure 4 showed the normalized tension of the SC and the TIC during one arm curling. The results showed that there were significant differences between SC and isotonic contraction in kinetics and muscle activation. In upper arm training, subjects using the stepwise loading system could lift up more weight than in the traditional isotonic loading system (t=5.34). As table 1, there are significant differences in the angle of peak tension and the normalized peak tension between the SC and the TIC, however the normalized impulse and the IEMG of the SC are higher than the TIC without significance. In slow motion, the angles of peak tension in the SC and the TIC were significantly different. Using the stepwise training system, the strength of the biceps brachii reached peak tension at an angle between 120 and 100 degrees. However, in traditional isotonic system peak tension was reached at an angle between 160 and 130 degrees which showed a significant difference (t=-13.872).

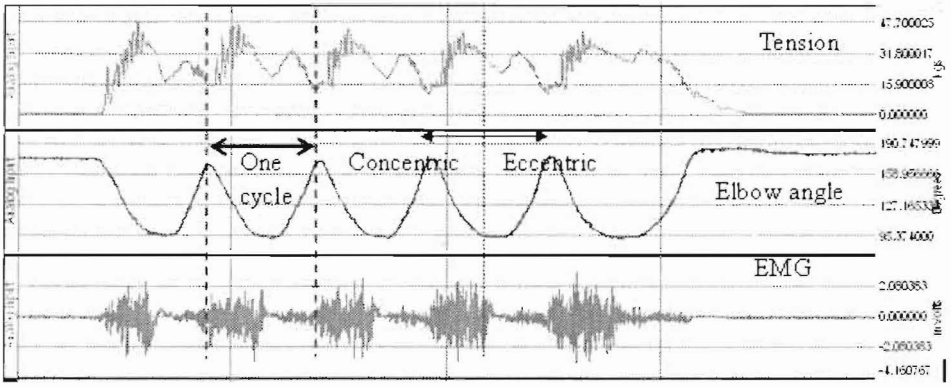


Figure 3: Raw data of the SLS.

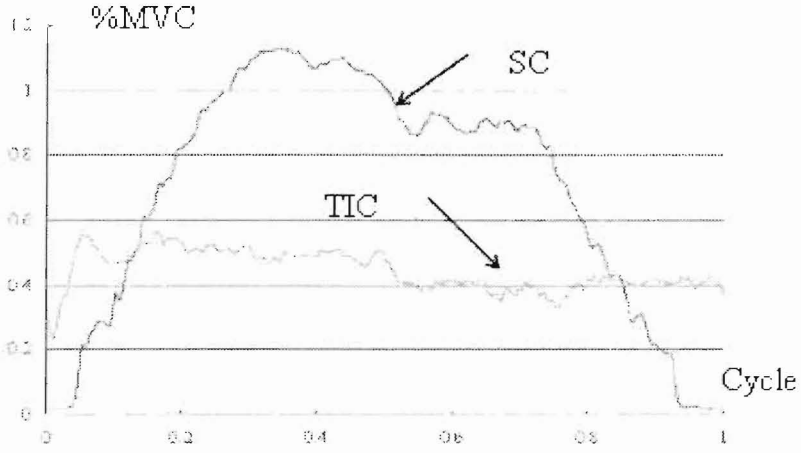


Figure 4: Normalized tension during one cycle of the SC and the TIC.

Table 1 All parameters with statistical analyses in the SC and the TIC.

	SC	TIC
	Mean ± SD	Mean ± SD
The angle of peak Tension	113.755 ± 0.141*	134.655 ± 0.141
Normalized peak Tension	1.131 ± 0.294*	0.565 ± 0.354
Normalized impulse	0.464 ± 0.141	0.439 ± 0.470
Normalized IEMG	1.203 ± 0.717	1.158 ± 0.481

*: P<.05

CONCLUSION: A traditional isotonic machine with the new design of the stepwise loading system would more efficiently to use in order to gain strength due to the exertion of maximum effort among all the range of motion. The findings suggest that stepwise loading system can provide greater stimulus to muscle training effect than traditional weight training systems. This study could provide more information about design a better weight-training device in an economical approach to improve strength for fitness and sport competition. However, further studies should be conducted to thoroughly investigate all the parameters of this new design device.

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