Comparison between Ideal and Actual Strength Curve Generated by Dumbbell/Barbell Biceps Curl Exercises for Biceps-A Review

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Abstract—A two-dimensional model was developed for dumbbell/barbell and cable biceps curl exercises, in quasi-static and isokinetic regimes. This study deals with the strength curve generated by the dumbbell/barbell biceps curl exercises. The concept of this study will be demonstrated in a barbell curl exercise, although the concept can also be applied to other forms of resistance training equipment’s. In this study, comparison of generated or actual strength curve that is obtained from dumbbell/barbell and cable biceps curl exercises with the ideal strength curve for biceps which is according to the biomechanics of elbow.

Key words: Schematic Model of Skeletal Muscle, dumbbell/barbell biceps curl exercises

I. INTRODUCTION

Muscles are structures that convert chemical energy into mechanical work and heat energy. In studying sport and exercise movements biomechanically, the muscles of interest are the skeletal muscles, used for moving and for posture. This type of muscle has striated muscle fibers of alternating light and dark bands. Muscles are extensible, that is they can stretch or extend, and elastic, such that they can resume their resting length after extending. They possess excitability and contractility. Excitability means that they respond to a chemical stimulus by generating an electrical signal, the action potential, along the plasma membrane. Contractility refers to the unique ability of muscle to shorten and hence produce movement. Each muscle fiber is innervated by cranial or spinal nerves and is under voluntary control. The terminal branch of the nerve fiber ends at the neuromuscular junction or motor end-plate, which touches the muscle fiber and transmits the nerve impulse to the sarcoplasm. Each muscle is entered from the central nervous system by nerves that contain both motor and sensory fibers, the former of which are known as motor neurons. As each motor neuron enters the muscle, it branches into terminals; each of which forms a motor end-plate with a single muscle fiber. The term motor unit is used to refer to a motor neuron and all the muscle fibers that it innervates, and these can be spread over a wide area of the muscle. The motor unit can be considered the fundamental functional unit of neuromuscular control. Each nerve impulse causes all the muscle fibers of the motor unit to contract fully and almost simultaneously. The number of fibers per motor unit is sometimes called the innervation ratio. This ratio can be less than 10 for muscles requiring very fine control and greater than 1000 for the weight-bearing muscles of the lower extremity. Muscle activation is regulated through motor unit recruitment and the motor unit stimulation rate (or rate- coding). The former is an orderly sequence based on the size of the motor neuron. The smaller motor neurons are recruited first; these are typically slow twitch with a low maximum tension and a long contraction time. If more motor units can be recruited, then this mechanism dominates; smaller muscles have fewer motor units and depend more on increasing their stimulation rate.

A. Schematic Model of Skeletal Muscle

A simple schematic model of skeletal muscle is often used to represent its functionally different parts. The model used is normally similar to Figure 1, and has contractile, series elastic, and parallel elastic elements. The contractile component is made up of the myofibril protein filaments of actin and myosin and their associated coupling mechanism.

Fig. 1: Simple schematic model of skeletal muscle.

II. LITERATURE SURVEY

Jaykantgupla[1] examined the effects of these different carburization temperatures and conditions on the mechanical and wear properties of the carburized mild steels. For above purpose firstly the mild steels are carburized under the different temperature range as stated above and then it is tempered at 2000 C for half an hour after this the carburized and tempered mild steels are subjected for different kind of test such as abrasive wear test, hardness test, tensile test and the toughness test. The results of these experiment shows that the process of carburization greatly improves the mechanical and wear properties like hardness, tensile strength and wear resistance and these properties increases with increase in the carburization temperature but apart from this the toughness property decreases and it is further decreases with increase in carburization temperature.

Andrea Biscarini et al. [2] studied A two-dimensional model was developed for dumbbell/barbell and cable biceps curl exercises, in quasi-static and isokinetic regimes. Analytical expressions for the ratios of the biceps force (F) and the tangent (t) and normal (fn) components of the joint reaction to the dumbbell (Mg)
Comparison between Ideal and Actual Strength Curve Generated by Dumbbell/Barbell Biceps Curl Exercises for Biceps - A Review

(JISRD/Vol. 3/Issue 04/2015/429)

and cable (c) external load were deduced as a function of the joint angle q and the other relevant parameters. For standing/preacher dumbbell curl, F and fn take their maximum values at the critical wrapping angle q*=27.4°, for any value of the preacher bench inclination a within the range 0°<90°-q*. An increase of a yields: a) an increase in the initial value of F, and in the peak values of F and fn (up to 15Mg and 14Mg, respectively); b) a steeper decrease of F between q* and 180°-a where F=0; c) a shift of the f(t)curve towards lower joint angles. For a=38°, the joint load becomes of compressive type (f=0) within the whole range [0,180°-a] of the joint motion. In cable curl, high values of the distance dP of the elbow joint from the pulley center give the same results as the standing dumbbell curl (a=0). When dP approaches the smallest allowed values, the model predicts: a) a steep increase of F and a steep decrease of fn and ft, just above q=0; b) high peak values of F and fn at q=q* (up to 15c and 13c, respectively); c) tractive values of fn smaller than 2c and nearly constant values (~3c) of F, above q=100°.

Giovanni L. Fabian [3] introduced a new concept in the generation of strength curve profile in resistance training equipment’s. Rather than of using the conventional spiral off center cam commonly used in current resistance training equipment’s, this study focuses on using a DC motor to be controlled by a micro controller to generate the strength curve as well as the resistance in resistance training equipment’s. Unlike the spiral off center cam, the method in this study will not be hampered by the limitations imposed by using a mechanical component that usually lack flexibility in these equipment’s. The concept of this study will be demonstrated in a barbell curl exercise, although the concept can also be applied to other forms of resistance training equipment’s. With this study, a new and flexible alternative in the generation of strength curve profiles in resistance training equipment’s can be offered.

Tae Sik Yoon et al. [4] considered isometric and isokinetic torques of bilateral quadriceps and hamstrings were measured with Isokinetic Rehabilitation and Testing System (Model No. Cybex 340) on 40 normal untrained subjects, 10 males and 20 females, ranging between the ages of 23 and 35 years. The mean peak isometric and isokinetic torque values of both muscle groups showed no significant differences between dominant (right) and non-dominant (left) limbs in both sexes; however there were significant differences between the male and the female. As the angular velocity increased, the peak torque significantly decreased, and the point of peak torque output occurred significantly later in the range of motion for quadriceps and hamstrings (p<0.01). There were no significant changes in the hamstrings to quadriceps (H/Q) ratios as the angular velocity increased. However, there were significant differences of mean H/Q ratio between male and female (p<0.01). Height had significant positive correlation with peak isometric and isokinetic torques for both quadriceps and hamstrings (p<0.01). Weight was found to correlate significantly with peak isometric and isokinetic torques (p<0.01). TJe mean isometric torques were significantly higher than the mean isokinetic torques for any joint angles in both sexes (p<0.01).

Joseph J Knepik et al. [5] describe and examine variations in maximal torque produced by knee extension, knee flexion, elbow extension, and elbow flexion through a range of joint motion. Subjects were young, healthy men (n = 16) and women (n = 15). Torque was measured iso-metrically and iso-kinetically using a modified Cybex apparatus. Isotonic torque was calculated from one repetition maximum using a modified N-K® device. Joint angles were monitored with an electromyometer. Torque-joint angle curves were constructed for both men and women for each muscle group. Isometric torque was highest, followed by isotonic and iso-kinetic torque. Torque declined with increasing iso-kinetic velocity. The angle of peak torque was found to be highly variable in individual subjects. Variations in torque curves were explained in terms of mechanical characteristics of the musculoskeletal system. Muscle group capability was generally found to be well matched to the mechanical requirements of the movement.

Hong-Bo Xie et al. [6] studied of the chaotic nature of MMG signals by referring to recent developments in the field of nonlinear dynamics. MMG signals were measured from the biceps brachii muscle of 5 subjects during fatigue of isometric contraction at 80% Maximal voluntary contraction (MVC) level. Deterministic chaotic character was detected in all data by using the Volterra-Wiener Korenberg model and noise titration approach. The noise limit, a power indicator of the chaos of fatique MMGs signals, was 22.2078.73. Furthermore, we studied the nonlinear Dynamic features of MMG signals by computing the incorrelation dimension D2, which was 3.3570.36 across subjects. These results indicate that MMGIsa high dimensional chaotic signal and support the use of the theory of nonlinear dynamics for analysis and modeling of fatique MMG signals

III. F.B.D. FOR DUMBELL/BAR BELL BICEPS CURL EXERCISE

The dumbbell/barbell and the cable biceps curl exercises are schematized in Figures 2a and 2b, respectively. The observed mechanical system (represented in bold black in the figures) is the rigid body of mass composed of the forearm and the dumbbell (Figure 2a), or of the forearm and the cable handgrip (Figure 2b), according to the type of the equipment considered. The joint center of rotation J is assumed to be fixed. Thus, the position of the system is completely identified by the joint angle, individuated by the unit vector of the longitudinal forearm axis. When the forearm is fully extended may form an arbitrary angle with the descending vertical direction. In the dumbbell/barbell biceps curl a preacher bench is needed to support the arm for (Figure 2a).
Comparison between Ideal and Actual Strength Curve Generated by Dumbbell/Barbell Biceps Curl Exercises for Biceps: A Review

(www.ijsrd.com) 1844

IV. COMPARISON OF OBTAINED AND IDEAL STRENGTH CURVE FOR BICEPS

The degree of elbow flexion from the figure above is graphed against the percentage of muscular contraction of the biceps muscles (see Fig. 3) between the length-tension curve of the biceps muscles (A) and the effective, or actual resistance of a barbell curl (B), it can be seen in the difference (C) that the ideal strength curve of the biceps muscles (A) does not perfectly match the length-tension curve that it should be subjected to.

Fig. 2a

Fig. 2b

Figure 2 - Sketch of the dumbbell/barbell (Figure 2a) and the cable (Figure 2b) biceps curl exercises. The musculo-tendon actuator is modeled as a cable following an idealized minimum distance path from the origin (O) to the insertion (I) that may wrap around a cylinder of radius r, whose center coincides with the joint center of rotation J. A preacher bench, with variable inclination angle \( \alpha \), may be employed in dumbbell curl (Figure 2a). The pulley radius \( r_p \), the initial forearm inclination \( \alpha \), the distance \( d_p \) between the joint and the pulley centers of rotation and the cable load \( c_f \) are the adjustable cable parameters.

V. DISCUSSION AND CONCLUSION

The objective of this work was to study a model able to predict the value of the muscular force and of the joint reaction components during dumbbell/barbell and cable biceps curl exercises, in quasi-static and isokinetic regimes. These exercises are widely employed in all-level strengthening programs. It is widely accepted that the force a muscle exerts in dynamic conditions is related to the muscle architecture and is a function of the actual muscle length, the muscle fiber contraction velocity and the muscle activation level which is controlled by the central nervous system. Isokinetic free weight exercises require a subtle relationship among these parameters that has to be produced by a complex modulation of the activation level. Therefore, the understanding of the biomechanical differences between the dumbbell and the cable types of equipment, as well as of the effect of changes in the controllable parameters for each equipment is important for planning and customizing advanced exercises according to specific needs and demands.

The main limitations of the present model are associated with the simplifications involved in the musculo skeletal model of the elbow joint, such as its two-dimensionality, cylindrical shape and fixed center of rotation. In this study we observe that the shaded area (C) is the apparent difference between ideal resistance (A) and barbell resistance (B) for the biceps muscles. Therefore, in order to optimize growth in the human muscles, the resistance applied should exactly match the apparent change in strength of the human muscle. That is, a resistance that at no point over the range of movement would appear to be any heavier or lighter than at any other point. In order to do this however, the resistance needs to be varied along the entire range of motion to compensate for the change of strength of the muscle during contraction. This is the main reason of using spiral off centered cams in resistance training equipment’s to possibly duplicate the ideal strength curve.

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