New Automated Free Weight Device for Weightlifting and Resistance Training

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INTRODUCTION

Strength, power and endurance are recognised to be the essential components of physical fitness and pre-requisites to successful participation in sporting activities. In order to develop and maintain these ***(components of physical fitness)*** an individual has to take part in some form of resistance training.

A review of the literature on weight training reveals that several types of resistance training devices and programs can cause improvement in strength, power and endurance capacity of skeletal muscles. One of the most popular devices used by the athletes and general public are the free weights. The free weights comprise of a bar and set of weight plates to vary the resistance during training program. Training with free weights, often referred to a isotone training, has proven to be very effective in bringing about significant gains in muscular strength, power and endurance. It is also a very effective method of developing muscle hypertrophy. However, in spite of all the advantages, there are some inherent problems in training with the free weights.

a. ***Safety:*** It is of primary concern especially when training with near maximal weights. Serious injury can result if appropriate preventive measures are not taken and often one or two spotters are needed to assist an athlete when working with maximal or near maximal weights.

b. To make weight training specific to different sporting activities, it is often difficult to train using different types of muscle contractions, i.e. concentric, eccentric and isometric contractions. Physiologically manual tension generated bv a skeletal muscle is greater during eccentric and isometric contradtions as comoared to concentric contractions.

Therefore, the isometric and eccentric contractions normally can not be performed near maximal loads since the weight lifted cannot exceed the maximum for the concentric phase of the exercise.

DESIGN OF THE FREE-WEIGHT *DYNAMOMETER*:

To overcome the problems associated with free-weight training, and maintain all of its advantages, a new free-weight electric dynamometer has been constructed. The design of the dynamometer is shown in Figure 1. The dynamometer can be used both for testing and training purposes. While training an individual may perform the exercise isometrically, concentrically and eccentrically. The dynamometer also allows for isolation of different muscle groups along with different types of muscular contractions. It is very safe to use and there is no need of spotters. The dynamometer is built so that the active exercise phase is controlled by the subject and the passive phase by the exercise apparatus. The predetermined speed at which the weight loaded bar automatically returns to the starting exercise position is controlled by a gear reduction box connected to an electric motor. The speed once adjusted cannot be altered by the amount of resistance on the loaded weight bar. The speed control is a one way function through the *clutch* (N) located on the top right hand corner as shown in Figure 1.

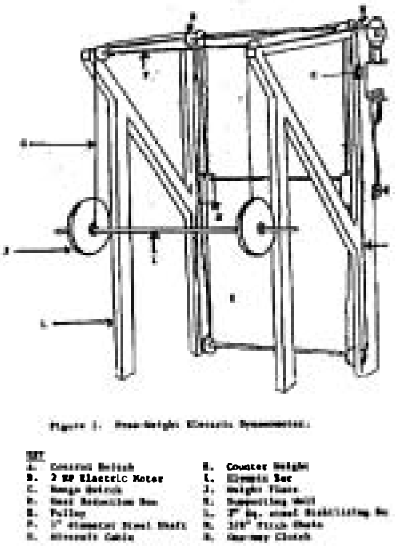

Figure 1: Free-Weight Electric Dynamometer

The height of the Olympic bar (I) is readjusted by triggering the control switch (A) to the off position. This shuts-off the electric motor. Then, the range switch (C) is readjusted to the newer position. Moving it upward or downward, on the *pitch chain* (M), adjusts the bar to the new starting position. During training or testing, once the weight loaded bar returns to the starting position, the function of the range switch is to trigger the micro switch off. Once the Olympic bar is at the original starting position the micro switch position is directly underneath the range switch (C). As the subject attempts to do another repetition the micro switch is triggered on to start the electric motor. If, for example, a subject lifts the bar for a concentric type muscle contraction of the lifting phase or when the subject ceases to support the bar. The dynamometer consists of a set of several pulleys (E) and metal supports (M) which assist in integrating functioning of the dynamometer and allow the weightloaded bar to be positioned about four feet (1.2m) away from the back wall (K). The parallel corresponding pulleys areconnected by one inch (2.5 cm) diameter steel shaft. (F). The shaft helps maintain a constant distance between the two corresponding pulleys and also their rotational speed so that the velocity of the two aircraft-cable (G) connected to the weight bar is the same on both ends. The posterior aspect of the dynamometer consists of two counter weights (H), **one** at each side. The combined weight of these two weights and the shaft between them is 45 pounds (20kg). Therefore, both weights in front and back counter balances each other. If there is no external weight added the net resistance on the Olympic bar is zero. The resistance is adjusted by changing the *weight plates* (J) on the bar. They come in various sizes. The whole frame of the dynamometer is supported by the back wall (K) and the metal supports (M). The horizontal distance of four feet (1.2m) from the wall allows more than adequate space for an individual to stand behind the bar to perform the desired exercises.

ISOLATION OF DIFFERENT *TYPES* OF CONTRACTIONS:

For concentric contraction, the equipment is designed so that it automatically returns the bar to the starting position within a specified time after a subject has completed the desired contraction. Because of this mechanism the eccentric part of the contraction is performed by the dynamometer allowing an individual to perform the concentric phase only (Figure 2). If desired, one may also perform submaximal isometric contraction with the concentric load on the bar. For multi-repetitions, as soon as the weight loaded bar comes back to the starting position, an individual lifts it again using the musculature under training (e.g. biceps curls, squats, etc.). This cycle continues until the desired number of repetitions is achieved.

For maximal isometric contractions the bar height is adjusted to the desired level. Then the bar is supra-maximally loaded in relation to the one repetition maximum (1 RM) of concentric force. The desired maximal isometric contraction then can be performed at that height. The height of the bar can be adjusted up or down, after completion of desired number of repetition(s) in order to allow an individual to train at different joint angles within the selected range of motion.

Figure 2: Isotonic Training on the Free-weight Electric Dynamometer

For eccentric training an individual is only required to lower the weight loaded bar from the present height. The concentric phase of the contraction is performed by the dynamometer automatically. The eccentric training contractions on the dynamometer can be performed at 110 to 130% of the maximal or more or concentric load (1 RM) without the need of any spotters.

RELATED RESEARCH WORK:

The free weight dynamometer has been used for research purposes at the University of Alberta. Two theses have been completed utilizing this apparatus (Chahal, 1988; Okoro, 1987). The device was used for both testing and training purposes. The test-retest reliability coefficient for testing of concentric leg extensions strength was observed for concentric leg extension and isometric back lift at hip angle of 160 degrees (p.). Through empirical and experimental observations the device has been demonstrated to be very safe to use. During concentric or eccentric contraction, if the subject could not complete the lift, the weight would not immediately drop on the floor. Instead, it returned to the starting position as soon as the subject stepped out from underneath the loaded bar. This mechanism ensured that no one got injured throughout testing or training with maximal resistance.

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