

Chapter 11

A Strength Training Machine with a Dynamic Resistance Control Function Based on Muscle Activity Level

Shunji Moromugi
Nagasaki University, Japan

Takakazu Ishimatsu
Nagasaki University, Japan

ABSTRACT

A unique machine for strength training is introduced in this chapter. This training machine dynamically controls the amount of electronically generated resistance to provide a varying resistance force that follows a desired pattern during the exercise. This pattern or trajectory of desired muscle activity levels can be easily set prior to exercise through an interactive panel on the computer screen. It is predicted that this technology could facilitate more safe and effective strength training. The methodology for the muscle activity-based resistance control and the mechanism of the proposed system are detailed using a leg press prototype machine. The unique training features offered by the prototype are presented with data recorded from demonstrations and experiments.

INTRODUCTION

It is known that adequate levels of exercise contribute to the preservation of health. Machine training is currently recognized as one of the easiest ways to accomplish exercise. With machine training, the user has the advantage of selectively training

individual muscles and specifying the burden of weight or resistance during the exercise.

However, the question arises of whether current machine training provides the most effective exercise for a given strength training goal. Users typically select the force of resistance before beginning an exercise, but the benefits of training result from the amount of muscle activity during the exercise rather than the amount of resistance.

DOI: 10.4018/978-1-4666-2196-1.ch011

Furthermore, due to bodily mechanics, muscle activity levels can vary during the exercise even under a constant level of resistance. While current machine training controls the force of the resistance provided by the machine, the exact amount of muscle activity at each moment during the exercise is neglected. This study proposes that for a given training goal, there may be an ideal trajectory of muscle activity levels throughout an exercise to obtain the most effective results. Monitoring user muscle activity and dynamically controlling the resistance force during the exercise based on this information can also ensure more safe and effective strength training.

BACKGROUND

Variable resistance training is an existing technique in the field of physical training. It is intended to apply varying resistance force to the body and is delivered either manually by a therapist or through mechanical equipment such as cams and linkage mechanisms. Training machines for variable resistance training are designed to provide a constant load to the body throughout the range movement. A method known as isokinetic training (Jones, Rutherford & Parker, 1989) allows users to perform exercises at a constant speed using a uniquely designed hydraulic machine. This training method is intended to provide a well-balanced load on the muscles throughout the range of motion. Hitachi Medical Corporation Inc. has developed a training machine that alters the amount of training load based on exercise speed (Niigata Industrial Creation Organization, Hitachi Ltd., 2008). However, this machine does not allow the user to freely select the trajectory of the muscle load over the course of the exercise.

In contrast to the approaches mentioned above, the aim of the present study is to develop a training machine that allows the user or trainer to specify a variable resistance force based on individual goals.

PROPOSED SYSTEM

In this study, we propose a unique training machine that provides a variable resistance force controlled based on muscle activity. The machine allows users to design exercises employing various muscle activity patterns. This training machine is also user-friendly and does not require a complicated installation of sensors for muscle activity measurement.

Muscle Activity Sensor

In this study, physical stress on the body is evaluated based on the magnitude of the resistance force and the activity level of the target muscle. This muscle activity is measured by a Muscle Activity Sensor (MAS) that we have designed and employed previously. The sensor can be worn over clothing and is situated over the target muscle by simply wrapping an elastic belt or cuff over the sensor. We have previously developed various wearable devices using this sensor as a human-machine interface to facilitate the activities of elderly and disabled people (Moromugi et al., 2003a, 2003b). Figure 1 depicts the MAS. The sensor has two main components: a flat disk and a button in the center of the disk. The flat disk is 32 mm in diameter and 8 mm thick; the button is 6 mm in diameter and 4 mm in height. The weight of the sensor is 5 g. The sensor is strapped to the thigh to monitor the activity level of the vastus lateralis muscle, which is a portion of the quadriceps muscle that predominantly functions to extend the knee joint. Reaction forces from the skin on the button and on the sensor itself are measured by two pressure transducers. The level to which the target muscle is stiffened can be evaluated from changes in balance between the two forces measured. The level of muscle activity can be estimated from the sensor data because it is directly related to the magnitude of increased stiffness.

7 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage:

www.igi-global.com/chapter/strength-training-machine-dynamic-resistance/70852

Related Content

Development of an Affordable Myoelectric Hand for Transradial Amputees

Alok Prakashand Shiru Sharma (2020). *International Journal of Biomedical and Clinical Engineering* (pp. 1-15).

www.irma-international.org/article/development-of-an-affordable-myoelectric-hand-for-transradial-amputees/240742

Access Control for Healthcare

Yifeng Shen (2009). *Medical Informatics: Concepts, Methodologies, Tools, and Applications* (pp. 1920-1929).

www.irma-international.org/chapter/access-control-healthcare/26346

Proposed Solution to the Problem of Thermal Stress Induced Failures in Medical Electronic Systems

V. Lakshminarayananand N. Sriraam (2014). *International Journal of Biomedical and Clinical Engineering* (pp. 33-41).

www.irma-international.org/article/proposed-solution-to-the-problem-of-thermal-stress-induced-failures-in-medical-electronic-systems/127397

Localization of Characteristic Peaks in Cardiac Signal: A Simplified Approach

Subash Khanaland N. Sriraam (2015). *International Journal of Biomedical and Clinical Engineering* (pp. 18-31).

www.irma-international.org/article/localization-of-characteristic-peaks-in-cardiac-signal/136233

Development of an Affordable Myoelectric Hand for Transradial Amputees

Alok Prakashand Shiru Sharma (2020). *International Journal of Biomedical and Clinical Engineering* (pp. 1-15).

www.irma-international.org/article/development-of-an-affordable-myoelectric-hand-for-transradial-amputees/240742