ORIGINAL ARTICLE

# Resistance Training Improves Muscle Function and Body Composition in Patients With Hyperthyroidism

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ABSTRACT. Bousquet-Santos K, Vaisman M, Barreto ND, Cruz-Filho RA, Salvador BA, Frontera WR, Nobrega AC. Resistance training improves muscle function and body composition in patients with hyperthyroidism. Arch Phys Med Rehabil 2006;87:1123-30.

**Objective:** To evaluate the effect of resistance training on skeletal muscle performance and body composition in patients with medically treated hyperthyroidism.

**Design:** Nonrandomized controlled trial.

**Setting:** Large public tertiary hospital.

**Participants:** Sixteen sedentary patients with recent clinical diagnosis and laboratory confirmation of hyperthyroidism (7 men, 9 women; age, 38±11y; weight, 58.4±2.6kg; height, 1.6±0.3m) were assigned to the control group (medical therapy; n=9) or training group (medical therapy associated with resistance training; n=7). An age- and sex-matched healthy group served as controls (3 men, 5 women; age, 40±3y; weight, 68.4±4.3kg; height, 1.6±0.3m).

**Intervention:** Resistance training twice a week for 16 weeks.

**Main Outcome Measures:** Peak muscular strength (by dynamometry and 1 repetition maximum method) and endurance (30% of peak force) for 7 movements and anthropometric measurements.

**Results:** The hyperthyroid patients as a group had lower baseline overall strength values when compared with healthy subjects (200.3±16.0kg vs 274.9±21.8kg, respectively; $P=.006$). Overall absolute increases in strength (49kg vs 91kg, $P<.05$) and endurance ($78.5\times10^2$kg/s vs $176.9\times10^2$kg/s, $P<.05$) were higher in the training group compared with the control group. Body weight increased in both groups, but the sum of muscular circumference increased only in the training group (training group, 92.6±3.3cm vs 97.1±3.8cm; control group, 94.6±2.2cm vs 94.4±2.1cm; $P<.05$), with no change in the sum of skinfolds.

**Conclusions:** Resistance training accelerates the recovery of skeletal muscle function and promotes weight gain based on muscle mass improvement in patients with medically treated hyperthyroidism.

**Key Words:** Anthropometry; Exercise; Hyperthyroidism; Muscle, skeletal; Rehabilitation.



HYPERTHYROIDISM IS A PATHOLOGIC syndrome in which tissue is exposed to excessive amounts of circulating thyroid hormone. Graves' disease, an autoimmune condition caused by stimulation by antibodies directed against the thyrotropin receptor, is the main cause of hyperthyroidism.[1,2] Serum concentrations of the 2 thyroid hormones, thyroxine and tri-iodothyronine, are increased, and levels of thyrotropin are greatly reduced. Thyroid hormones regulate many physiologic functions such as energy and heat production, synthesis of proteins, and muscle function. Thus, symptoms of hyperthyroidism may involve fatigue, tremor, weight loss, and a general muscle weakness; these are part of the initial clinical manifestation in about 80% of patients.[3,4] The skeletal muscle dysfunction can be severe in patients newly diagnosed with Graves' disease, compromising their abilities to perform simple daily activities such as self-care tasks. Another important component of the hyperthyroid-induced myopathy is atrophy, which seems to affect proximal more than distal muscle groups and is a contributing factor for the decrease in absolute muscle strength and functional capacity.[4] It has been suggested that although the muscle protein synthesis rate is not affected by the disease, the muscle protein breakdown is increased up to 40%, contributing to the 10% to 20% decrease in muscle mass and function typically observed before any treatment.[5] Other symptoms can include a lower proportion of type I fibers, greater capillary density, lower glycogen content, and higher hexokinase activity during the hyperthyroid state.[6]

Medical treatment for hyperthyroidism (pharmacologic therapy, radioactive iodine treatment, surgery) has been shown to be effective in improving muscle function and restoring body composition. However, these changes are time dependent, and complete recovery—including recovery of muscle function—may not be achieved for up to 1 year after treatment initiation.[7] The time course (and distribution) of the recovery of skeletal muscle mass and intraperitoneal adipose tissue has been described for the first 3 months of treatment for hyperthyroidism.[8] Also, an increase in strength up to 40% was observed when patients were tested in the euthyroid state after a 12-month treatment period.[9] The improved muscle performance seen with treatment of hyperthyroidism is due to enhanced intrinsic muscle function and a greater muscle mass. However, muscle endurance—defined as the maximal time a load can be sustained—does not reach healthy control values.[10] This finding may have practical clinical implications because muscle endurance is closely related to the ability to perform daily life activities.

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Resistance training, or strength training, involves the voluntary activation of specific skeletal muscles against some form of external resistance and is considered an effective method for developing musculoskeletal strength and endurance.[11,12] Although the benefits of resistance training are well described in many pathologic situations, its effect in patients with hyperthyroidism has never been studied. Considering the typical muscle wasting observed in hyperthyroidism and the known physiologic adaptations in response to resistance training, it is conceivable that resistance training could accelerate the recovery of muscle mass and performance in patients with hyperthyroidism, a hypothesis that has not been tested previously. If the results of the present study suggest that indeed resistance training has a beneficial effect for hyperthyroid patients, the prescription of this type of training would be a key element in the treatment for hyperthyroidism, improving functional status and quality of life.

The purpose of the present study was to evaluate the effect of resistance training in the recovery of skeletal muscle performance and body composition in patients with hyperthyroidism who were currently under medical treatment.

## METHODS

### Participants

Twenty-two sedentary patients with a recent clinical diagnosis and laboratory confirmation of Graves' disease were referred to the endocrinology outpatient clinic at the Antonio Pedro University Hospital and invited to take part in the study. Patients with any other concurrent diseases, infiltrative ophthalmopathy, or any orthopedic limitations making them unable to perform the tests were excluded. A group of healthy volunteers (n=8) without any history of thyroid disease was also recruited at the university. This healthy control group was selected from a larger population who volunteered for the study and served as an age- and sex-matched group for comparison with the patients. All volunteers engaged in the study were sedentary and none of them had participated in an exercise-training program for at least 6 months previously. The study was approved by the institutional review board, and each subject gave written informed consent.

### Study Protocol

After the diagnosis of hyperthyroidism was confirmed, patients underwent a baseline evaluation consisting of body composition assessment and skeletal muscle performance tests, both conducted on the same day. Medical treatment started after this first evaluation and included antithyroid therapy (propylthiouracil or methimazole) or radioactive iodine ($^{131}I$). The attending physician was independently responsible for decisions regarding medical treatment. After baseline evaluation, subjects were divided into 2 groups: a control group consisting of patients receiving medical treatment and a training group consisting of patients receiving medical treatment plus resistance training. Subjects were assigned to each group depending on their availability to engage in the training program. All patients were reevaluated after 16 weeks. Subjects in the training group were reevaluated at least 48 hours after the last exercise training session. Laboratory tests, including thyroid-stimulating hormone (TSH) and free thyroxine ($FT_4$)[a] were performed at the beginning and end of the study. Subjects in the healthy control group underwent body composition assessment and skeletal muscle performance tests just once.

### Skeletal Muscle Performance

Muscle strength was determined for 2-leg knee extension, right- and left-knee flexion, ankle plantarflexion, and supine bench press[b] by the 1 repetition maximum method (1-RM). Right- and left-handgrip strengths were measured with hand dynamometry.[c] One repetition maximum was defined as the highest load that could be lifted through the full range of motion.[12] For the hand dynamometry, peak strength was considered the highest force generated in 3 trials (alternating left and right hands), each lasting 2 to 5 seconds and separated by a 1- to 2-minute interval. Muscle endurance was calculated by asking patients to sustain a load equivalent to 30% of the 1-RM as long as possible without changing the joint angle. The result of this test was quantified by load multiplied by time (in kg/s). Handgrip endurance was also calculated using the longest time to sustain 30% of peak force. A rest period of 15 to 30 minutes between strength and endurance evaluation was allowed. The sums of the values for strength and endurance were used to estimate overall strength and endurance, respectively. Variability in endurance measurements was minimized by (1) having only 1 evaluator involved in the procedure, (2) using the same equipment before and after the intervention, (3) always performing the tests at the same period of the day, (4) using a standard verbal support to each volunteer to hold the static contraction, and (5) interrupting the test whenever the joint angle changed despite the continuous standard verbal support. Under these conditions the intrasubject coefficient of variation was 5% to 15%.

### Body Composition

Anthropometric measurements included height, body weight, skinfold thickness using a Harpenden[d] caliper (biceps, triceps, subscapular, suprailiac, supraspinal, abdominal, thigh, calf), circumferences using a nonelastic tape (arm, forearm, chest, waist, gluteal, thigh, calf), and bone widths measured with a modified Mitutoyo[e] caliper (distal humerus, femur). The measurement protocol was guided by procedures using standard anatomic landmarks.[13] Triplicate measurements were obtained, and the median values were used for analysis. All measurements were conducted by the same investigator who has an intrasubject reproducibility of 1% for circumferences and 5% for skinfolds. There is a general agreement that maximal reproducibility should be 2% for circumference and 10% for skinfold.[14] Limb circumferences (arm, thigh, calf) were corrected by the corresponding skinfold to yield an estimate of muscle circumferences using a linear geometric model, where muscle circumference = limb circumference − ($\pi \times$ limb skinfold).[15-17] Results from the 3 sites were added together to provide an index of overall limb muscle mass.

### Resistance Training

Patients performed strength-training sessions in our laboratory twice a week for 16 weeks. The physiologic adaptations to this type of training become evident after 8 to 12 weeks.[12,18] An interval of at least 24 hours between training sessions was allowed. Patients performed 3 sets of 7 maneuvers each. The 7 maneuvers were the same as those used for the initial evaluation: 2-leg knee extension, right- and left-knee flexion, ankle plantarflexion, supine bench press, and right and left handgrip. Each individualized supervised session lasted approximately 50 minutes. In the first sessions, patients performed 60% to 80% of the 1-RM previously determined in the baseline evaluation. One complete circuit consisted of 8 to 10 repetitions of the 7 maneuvers performed in 3 series with a maximum 2-minute rest between each set of maneuvers. Weight progres-