Turkish Journal of Endocrinology and Metabolism, (2000) 2 : 55-61 **ORIGINAL ARTICLE**

The Assessment of Anthropometric Measurements, Muscle Strength, Flexibility, Energy Consumption and Pulmonary Function in Hyperthyroid Patients Before and After Medical Treatment

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This study was performed to compare the changes in anthropometric measurements, muscle strength, flexibility, energy consumption and pulmonary function before the treatment of hyperthyroidism and in euthyroid status after antithyroid treatment in previously hyperthyroid patients.

Eight (5 female, 3 male) hyperthyroid patients (mean age: 43.38±13.51 years) participated in the study. The anthropometric measurements, manual muscle test, hand grip strength test with a Jamar dynamometer, the test for 1 maximum repetition of the Quadriceps femoris muscle (1 max of QF) and flexibility tests were done both prior to the antithyroid treatment and after the patients returned to euthyroid status. Energy consumption was measured using the "physiological cost index", also pulmonary functions (VC, FVC, FEV1) were tested using a spirometer.

When the results obtained before the treatment and in euthyroid status after antithyroid treatment were compared, increases in the muscle strengths in the neck, trunk, scapula (p<0.05), upper, lower extremities (p<0.001) and the flexibilities of Quadriceps femoris (QF) and trunk extension (p<0.001) were statistically significant in the euthyroid status. The increases in the hand grip strength and the 1 max of QF (p<0.001) were also significant. The body weight increased (p<0.05) but, there were no statistically significant differences in the other anthropometric measurements or pulmonary function. The energy consumption decreased in euthyroid status (p<0.01).

The present study demonstrated that the medical treatment of hyperthyroid patients resulted in a marked increase in muscle strength and a decrease in energy consumption while there were no statistical significant differences in the anthropometric measurements, except body weight, before and after treatment.

Key words: Hyperthyroidism, anthropometric measurement, muscle strength, flexibility, energy consumption, pulmonary function

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Introduction

Hyperthyroidism is associated with general muscle weakness, which is part of the initial clinical manifestation of about 80 % of patients. Another important component of thyrotoxic myopathy is muscle atrophy. Muscle atrophy causes to the decrease in muscle strength (1-9) and some changes in the anthropometric measurements may occur (10, 11). The mobility of joints and muscles is assessed using flexibility tests (12-15). The systematic assessments of the body composition and flexibility in hyperthyroid patients have not been sufficiently investigated.

In addition, exercise tolerance is also impaired in this group of patients (6, 16). Dyspnea at rest and in exercise is reported as a common symptom of hyperthyroidism, the tissue oxygen requirement grows sharply due to the activation of catabolic processes and intensified heat production. Vital capacity is commonly reduced; this reduction appears to result mainly from weakness of the respiratory muscles, but decresed pulmonary compliance may also play a role (10).

The aim of this study was to assess the changes in anthropometric measurements, muscle strength, flexibility, energy consumption and pulmonary function before the treatment of hyperthyroidism and in euthyroid status after antithyroid treatment in previously hyperthyroid patients.

Patients and Methods

Eight patients (5 women and 3 men) admitted to the Department of Endocrinology who had not had antithyroid treatment before, were diagnosed as hyperthyroid. There were Graves' disease in 5 patients and toxic multinodular goitre in 3 patients. None of the patients had any clinical or laboratory signs or a history of pulmonary disease. No other concurrent diseases were present either. Two were smokers, 2 were ex-smokers, and 4 were non-smokers. The patients were informed about the procedures and signed informed consent before entering the study. Blood samples were collected from patients both prior to the treatment and after the patients returned to euthyroid status. Serum total T4, total T3, free T4, free T3 and TSH were analyzed using chemiluminescence assay with an ASC-180 autoanalyzer.

After the diagnosis was established, first evaluations were performed on the same day. Following these evaluations, patients were treated with the antithyroid drug, propylthiouracil. Patients were submitted to periodical clinical and laboratory evaluations until the euthyroid status was achieved. During the treatment period (4.1 months), the patients did not participate in any exercise training and did not alter their physical activity level.

Anthropometric mesurements: They included the values of height (cm), weight (kg), body composition [body mass index (BMI), (kg/m^2), percent body fat, lean, water] and the sum of the circumferences of the limbs (upper arm, forearm, thigh and calf) in centimeters (cm). Body composition was measured by Bioelectrical Impedance Analysis using Bodystat 1500.

Muscle strength: The manual muscle test described by Levett, which is scored from 0 to 5, was used to evaluae the strength of the muscle groups and some specific muscles on the dominant side (14, 18,19). This test was applied for the flexors and extensors of the neck, trunk, elbow, knee and wrist; the elevator, depressor, abductor and adductors of the scapula; the flexor, extensor, abductor, internal and external rotators, horizontal abductor and adductor of the shoulder; the supinators and pronators of the forearm; the flexors, extensors, abductor and adductor of the fingers of the hand, the Gastrocnemius-Soleus, Tibialis anterior and posterior, Peroneus longus and brevis muscles. The sum of the strength values of the muscles in each of the neck, scapula, trunk, upper and lower extremities was calculated. In addition, the sum of the strengths of all muscles assessed was calculated.

To assess the 1 max of QF, the patient was seated in an adjustable straight-backed chair with the lower leg dependent and knee flexed to 90°. The patient's ankle was fixed with a nonextensible strap looped around the proximal to the malleoli. Weights were put on the setting in the ankle. The maximum weight that the patient could raise only once in full knee extension on the dominant side was determined in kilograms (kg) (20).

The hand grip strength was assessed using a standard adjustable-handle Jamar dynamometer. Standard positioning (21, 22) and verbal instructions were used. The mean of three trials on the dominant side was calculated and recorded as representing each subject's maximum hand grip strength.

Flexibility tests: The flexibility was evaluated with 4 different tests; the extension, flexion, lateral flexion of trunk and QF on the dominant side. Each subject submitted to these tests according to the published protocol (13-15). The measurements were recorded in cms.

The energy consumption: This was determined using a "physiological cost index" (PCI) (23). In the patients the heart rates at rest and at the end of walking 250 meters and the time (minute) to complete the walking distance were measured. It was calculated as follows;

PCI = (heart rate walking - heart rate resting) / velocity.

The calculation was made using consistent units, with the heart rate in beats per minute and velocity in meters per minute.

Pulmonary function test: Vital capacity (VC), forced vital capacity (FVC) and forced expiratory volume in one second (FEV 1) were measured with a dry spirometer (Vitalograph Model S). All volumes were expressed as the percentage of the predicted values (24). This test was always performed by the same technician.

Investigations were repeated after the euthyroid status was achieved.

Statistical a nalysis: This was made using students paired t-test to evaluate statistically significant differences in the mean values between pre- and post-treatment data in patients. Pearson correlation coefficient was calculated to determine the relationship between variables. A p-value less than 0.05 was considered to indicate statistical significance. Data are presented as mean ± standard deviation (SD).

Results

The thyroid functions of the patients before and after the treatment are shown in Table 1. The body weight increased after antithyroid therapy ($p<0.05$). BMI, the percent of the fat, lean and water, and the sum of the limb circumferences increased but they were not statistically significant ($p>0.05$), (Table 2).

The muscle strengths in the neck ($p<0.05$), trunk ($p<0.05$), scapula ($p<0.05$), upper ($p<0.001$) and lower ($p<0.001$) extremities increased significantly, when the results obtained before the treatment and in euthyroid status were compared (Figure 1). The increases in the values of the 1 max of QF and the hand grip strength were statistically significant ($p<0.001$) (Figure 2, Figure 3). There was a correlation between the lean body mass and the sum of the strengths of all muscles assessed in the evaluation after the antithyroid treatment ($r = 0.08925$), ($p<0.01$).

Table 1. The comparison of the pre-and post-treatment thyroid functions of patients.

Thyroid functions	Pre-treatment $\bar{x}$ SD	Post-treatment $\bar{x}$ SD	P values
T3 (ng/ml)	4.46±1.4	1.21±0.29	<0.01
T4 (μ/dl)	19.95±4.78	8.02±2.21	<0.01
FT4 (ng/dl)	3.36±0.51	1.41±0.55	<0.01
TSH (μU/ml)	0.02±0.03	1.25±1.70	>0.05

Table 2. Pre-and post-treatment anthropometric measurements of patients.

	Pre-treatment $\bar{x}$ SD	Post-treatment $\bar{x}$ SD	P values
Weight (kg)	59.75±9.06	64.31±8.61	<0.05
BMI (kg/m^2)	22.10±3.41	24.07±3.00	>0.05
Limb circumferences (cm)	122.71±10.22	127.50±7.61	>0.05
Fat (kg)	16.13±7.13	19.43±7.7	>0.05
(%)	26.86±10.69	30.05±10.80	>0.05
Water (lt)	33.12±5.36	33.55±5.11	>0.05
(%)	55.52±11.17	55.56±8.07	>0.05
Lean (kg)	43.43±9.72	44.87±8.81	>0.05
(%)	69.95±10.80	73.13±10.65	>0.05

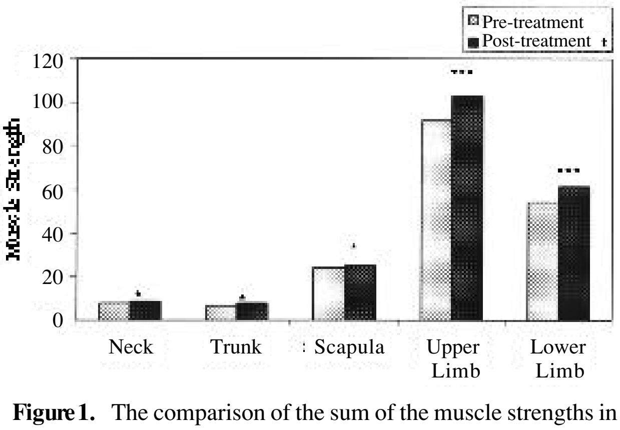

Figure 1. The comparison of the sum of the muscle strengths in the neck, trunk, upper and lower extremities, pre- and post-treatment (*=p<0.05; ***=p<0.001).

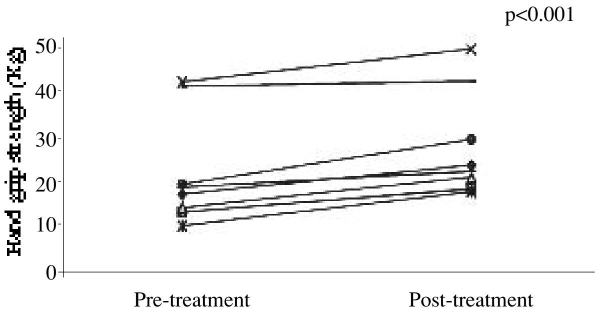

Figure 2. The pre- and post-treatment hand grup strength.

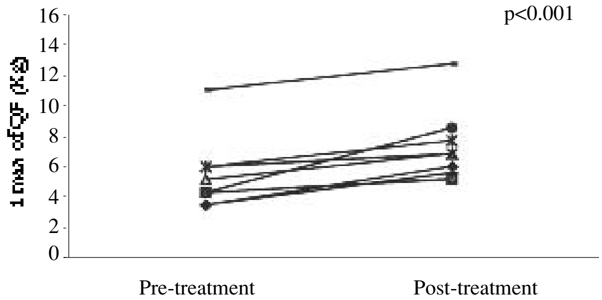

Figure 3. The pre- and post-treatment. 1 max of QF.

In the flexibility tests, the flexibilities of the trunk extension and QF increased at the second evaluation ($p<0.05$) (Figure 4).

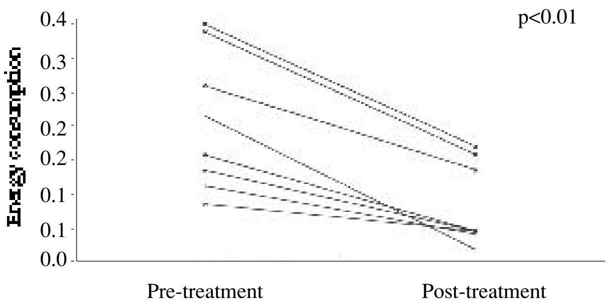

Figure 4. The pre- and post-treatment energy consumption (beats per meter).

The energy consumption decreased significantly after the antithyroid treatment ($p<0.01$) (Figure 5).

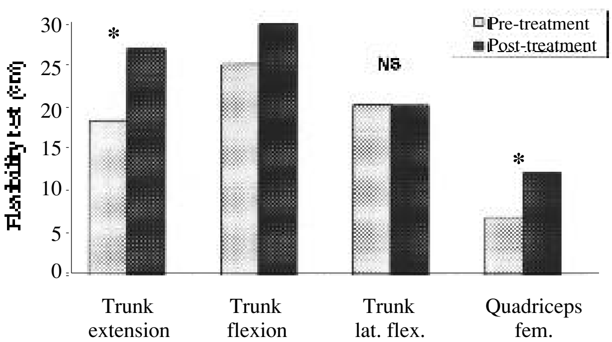

Figure 5. The pre- and post-treatment flexibility test (*p<0.05), NS=nonsignificant.

There were increases in the VC, FVC and FEV 1 but they were not statistically significant ($p>0.05$) (Table 3).

Table 3. Pre-and post-treatment pulmonary function tests.

Test	Pre-treatment $\bar{x}$ SD	Post-treatment $\bar{x}$ SD	P values
VC (%)	94.75±14.34	107.50±10.40	>0.05
FVC (%)	95.75±12.57	101.37±9.47	>0.05
FEV_1 (%)	102.25±14.22	106.37±5.42	>0.05

Discussion

Anthropometric measurements have been used widely as indicators for various conditions related to health (25). It is a common finding that the body weight decreases in hyperthyroid patients. Previous studies have shown a decrease in body weight in hyperthyroidism and an increase in it after antithyroid therapy in human and animals (1,11,26,27). In the present study also, the body weight of the hyperthyroid patients increased after antithyroid treatment.

We established significant increases in the muscle strengths assessed with a manual muscle test. This test is not as objective as those performed with a dynomometer and other instruments. But its application by the same, experienced physiotherapist increases its value. However, we also showed significant increases in the muscle strengths assessed using the hand grip strength test and the 1 max of QF, which were measured objectively. The general increase in the musle strength was associated with an insignificant increase in the lean body mass in this study. It was explained that appropriate oral, enteral, or intravenous refeeding elicits an improvement in hand grip strength within days; circumferential measurements of the arm however, respond more slowly over a period of weeks (25). This explanation corroborates our findings related to the significant increase in the muscle strengths as opposed to the insignificant increase in the sum of the circumferences of the limbs and the percent of lean body mass. Celsin et al (26) showed that maximal voluntary isokinetic knee extensor muscle strength increased markedly in 10 hyperthyroid patients after medical therapy. Similarly, Nobrega et al (27) evaluated 9 patients with Graves' disease. The muscle strength and endurance of the muscle groups (hip flexion, ankle dorsiflexion, and handgrip) and the sum of skinfold-corrected limb circumferences increased after the treatment of hyperthyroidism.

On the other hand, we thought that intrinsic factors could affect the increase in the muscle strength without significant improvements in the sum of the circumferences and the percent of the lean body mass. Investigators have reported that the alteration of nervous control of skeletal muscle (28), metabolic changes in the skeletal muscle (8,27,29) and the promotion or inhibition of the expression of various genes coding for contractile proteins (30) could cause the impaired intrinsic muscle function and its recovery after antithyroid therapy. Painless muscle weakness and atrophy develop gradually and vary from mild to severe. It is due to both muscle wasting, and decreased efficiency of muscle contraction (6,7). Muscle weakness may be due to the effect of T3 on ion channels and membranes. Severe thyrotoxicosis has been associated with muscle wasting, thought to be secondary to the hypermetabolic state. Effective skeletal muscle contraction is dependent on calcium release from the sarcoplasmic reticulum. After contraction, relaxation requires calcium reuptake mediated by Sarcoplasmic Reticulum Calcium ATPase (SERCA). SERCA 1 and SERCA 2a are expressed in the fast and slow muscle fibers, respectively. Interestingly, a sufficient level of T3 is required for the development and maintenance of fast skeletal muscle fibers. A sufficient level of T3 can induce a shift from a slow-fiber predominance to a fast-fiber predominance in adult skeletal muscle tissue. This finding implies that thyrotoxicosis might not only reduce muscle mass volume but also influence the fiber consistency of skeletal muscle. T3 directly regulates the rate of transcription of the gene for SERCA 1 (8). The degree of muscle weakness is roughly correlated with the severity and duration of the thyrotoxic state. Muscle weakness resolves when patients become euthyroid (9).

In this study, it has been shown that the restoration of normal serum thyroxin levels via antithyroid therapy improved muscle weakness.

The flexibilities of the extension of trunk and QF increased significantly. Ramsay (1) reported that the muscles most affected by hyperthyroidism were especially the extensors. Therefore, significant improvements in the flexibility that is related to muscle strength and joint mobilit may occur in the extensor group muscles of trunk and knee after the drug therapy. The same condition may also be valid for the value of the 1 max of QF.

In hyperthyroidism, the stimulation of energy metabolism and heat production is reflected in the increased basal metabolic rate (10). As a general rule the energy consumption is related to the difference in heart rate between the resting condition and that measured during exercise. Rather than attempting to relate the change in heart rate directly to energy consumption, some investigators use the "physiological cost index" (PCI) which is said to be less sensitive to differences between individuals (23). In our patients, the energy consumption decreased after antithyroid treatment.

Respiratory distress is often a complaint of hyperthyroid patients and may be due to any of several mechanisms. A typical symptom is extreme shortness of breath on climbing stairs. This symptom may be a reflection of weakness of the respiratory muscles. Cardiac contractile reserve can decrease. Weakness of skeletal muscles may also contribute to this complaint. Other abnormalities that contribute to respiratory compromise include decreased vital capacity, decreased lung compliance, increased minute ventilation, an enlarged pulmonary capillary bed and high output left ventricular failure (6,9,31-34). Rarely, the enlarged thyroid gland which accompanies hyperthyroidism puts pressure on the trachea and causes shortness of breath, stridor and wheezing. Alveolar and arterial oxygen and carbondioxide content and airway resistance are usually normal, although thyrotoxicosis can aggravate asthma. Ventilatory response to hypoxemia and hypercapnea are increased. In detailed ventilatory studies of hyperthyroid subjects, it was shown that the respiratory demand per increment of work load was normal, but the rate of oxygen consumption was abnormally high. There was a reduction in vital capacity and an increase in residual lung volume that was due to a lowered expiration reserve volume, since the functional residual capacity approximated the predicted value. These functions that depend on a sustained and forceful muscular effort were reduced, and therefore if muscle weakness limited tidal volume, a patient with hyperthyroidism would be able to maintain alveolar ventilation only by increasing respiratory frequency. These interpretations may explain the rapid, shallow breathing typically observed both at rest and on exercise (35).

The results of our study showed that in hyperthyroid patients, lung volumes did not alter to the percentage of predicted values. Small increments in lung volumes were not singificant. Therefore, it was thought that the complaint of dyspnea especially on exertion was probably due, at least in part, to the patients' awareness that a greater frequency of respiration was required in comparison with the pattern in a former euthyroid status. However, it has been shown that in subjects with respiratory muscle weakness, the decrease in lung volume is often less than would be suggested by the loss in muscle force (36). As the degree and duration of thyrotoxicosis might be important factors in determining whether an individual subject would manifest changes in respiratory muscle function (37) and as the number of our patients was small, it would not be correct to declare an opinion about respiratory muscle strength in hyperthyroidism with the patient subpopulation included in this study.

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