

CLINICAL STUDY

Body mass reduction markedly improves muscle performance and body composition in obese females aged 61–75 years: comparison between the effects exerted by energy-restricted diet plus moderate aerobic-strength training alone or associated with rGH or nandrolone undecanoate

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Abstract

Objective: To investigate the effectiveness of a body mass reduction programme entailing diet caloric restriction and moderate physical activity with or without supplementary treatment with recombinant (r) GH or steroids to improve body composition and muscle performance in severely obese women aged 61–75 years.

Methods: Twenty women were randomly assigned to one of three groups: body mass reduction alone; body mass reduction plus rGH; body mass reduction plus nandrolone undecanoate. Body composition, isotonic muscle strength and anaerobic power output during jumping were determined before and after the 3-week period.

Results: Whatever the experimental group considered, body mass ($P < 0.01$), body mass index ($P < 0.05$) and fat mass ($P < 0.05$) decreased significantly, whereas muscle strength and power increased significantly ($P < 0.05$) after the intervention.

Conclusion: Small body mass reductions after 3 weeks of energy-restricted diet combined with moderate aerobic and strength exercise are associated with significant improvements in upper and lower limb muscle strength and power and reduction of fat mass in severely obese women aged 61–75 years. Although the association of rGH or nandrolone undecanoate does not appear to exert additional effects on body composition and muscle performance attained by body mass reduction alone, further additional studies with larger study groups, different dosages and more prolonged periods are required for definitive conclusions to be drawn.

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Introduction

The beneficial effects of a short-term body mass reduction programme, including diet and combined aerobic and strength training, on body composition and physical performance have recently been demonstrated for severely (grade III) obese young patients (1). The outcome of similar procedures in elderly counterparts is, however, poorly known. Ageing is characterized by sarcopenia (2) – that is, the decline in muscle mass and strength that typically begins at about age 60 years (3) – and by a number of factors, for example decreased production and secretion of growth hormone (GH) (4), that inevitably ‘weaken’ the elderly individual. This situation is then further

aggravated in the case of the aged obese, as a result of the well-known negative effects of adiposity on the release of GH – a reduction in pulse frequency and decrease in GH half-life (5). A recent study from our laboratory indicated that women older than 50 years who have a high body mass index (BMI; $> 40 \text{ kg/m}^2$) can be considered to be the most disabled category in motor performance as a consequence of obesity, according to the low anaerobic power output of the lower limb muscles (6).

Since the landmark investigation by Rudman *et al.* (7), recombinant (rGH) has been administered to healthy elderly individuals to limit the impact of ageing in general. GH treatment has been found to decrease fat mass and increase lean body mass in non-obese elderly

women, even if these changes were accompanied by several side effects (8) and no improvement in exercise performance (9). However, little is known about the effects of low-dose pharmacological treatment (e.g. rGH or steroids) on the body composition and physical performance of obese elderly women.

This paper aimed at demonstrating whether a 3-week body mass reduction programme, including energy-restricted diet plus moderate aerobic and strength training, combined with rGH or nandrolone undecanoate treatment is more effective than body mass reduction alone in improving body composition and muscle performance in severely obese women aged 61–75 years.

Subjects and methods

Twenty obese female volunteers participated in a 3-week body mass reduction programme that included an energy-restricted diet (range: 1100–1500 kcal/day, calculated by subtracting approximately 20% from individual basal energy expenditure) containing 25% protein, 25–30% lipid and 45–50% carbohydrate, moderate aerobic and strength exercise (five sessions of 35 min/week), psychological counselling and educational lectures (see (1) for more details). All the patients gave their informed consent to participate in the study, which was approved by the Ethics Committee of the Istituto Auxologico Italiano, and they were randomly assigned to one of the three experimental groups. Eight women participated exclusively in the body mass reduction programme, with no pharmacological treatment (group BMR). Two groups of six patients received nandrolone undecanoate (80 mg i.m., administered weekly; group BMR + NU) or rGH treatment (0.1 IU/kg per week s.c., administered daily; group BMR + GH) during the 3-week period in addition to the body mass reduction programme.

At baseline, the three groups were matched in terms of age (BMR: 66.5±4.1 years; BMR + NU: 64.5±2.9

years; BMR + GH: 68.2±3.3 years; mean±s.d.) and body composition (Table 1).

Training

The typical training session consisted of 30 min of aerobic activities (10 min on a cycloergometer and 20 min on a treadmill) performed at 40–60% of individual maximal oxygen consumption ($\dot{V}O_2$ max), followed by 15 repetitions at 40–60% of one repetition-maximum (1-RM) load on three isotonic machines (Technogym, Gambettola, Italy).

Testing

Muscle performance and body composition were assessed before and at the completion of the body mass reduction treatment. Maximum anaerobic alactic power (W) output of the lower limb muscles was calculated during a series of five consecutive jumps by using the sum of the flight and contact time of jumps 2–5 (Optojump, Microgate, Bolzano, Italy), according to the formula proposed by Bosco *et al.* (10). Maximum strength was quantified as 1-RM load on two isotonic machines (leg- and chest-press). The same machines used during the training sessions were used for the evaluation, thereby retaining specificity between training and testing procedures (i.e. the muscle groups that had been trained were then tested in the same conditions). In addition, isometric bilateral handgrip was also measured with a Jamar dynamometer (Preston Corporation, Jackson, MI, USA) to investigate the effects of the 3-week intervention on muscle groups not specifically trained.

Body composition was determined by means of bioimpedentiometric analysis at frequencies of 1, 5, 10, 50 and 100 kHz using a tetrapolar impedance plethysmograph (Human-IM Scan, DS-Medigroup, Milan, Italy) and standardised procedures (11).

Concentrations of insulin-like growth factor (IGF)-I (Nichols Institute, San Juan Capistrano, CA, USA) and

Table 1 Pre- and post-treatment data from the three groups

	Group BMR (n = 8)		Group BMR+ NU (n = 6)		Group BMR+ GH (n = 6)	
	Pre	Post	Pre	Post	Pre	Post
Body mass (kg)	100.2±10.5	95.3±9.1***	102.3±11.9	98.5±10.7***	101.1±4.1	98.1±4.5**
BMI (kg/m ²)	38.9±2.6	37.4±2.3***	42.3±3.8	40.9±3.9***	39.5±3.0	38.4±3.3*
Fat mass (%)	53.1±3.9	50.5±3.8*	53.5±7.5	50.9±7.2**	53.0±4.6	50.6±5.0*
Fat-free mass (kg)	46.7±3.8	47.5±3.7	47.2±7.5	48.2±6.3	47.5±3.9	48.8±3.3
W jumps (W/kg)	5.0±1.8	6.0±2.6*	6.0±1.6	7.0±1.0**	6.0±2.6	6.8±2.1*
1-RM leg press (kg)	197.4±37.9	266.3±39.8**	249.8±22.7†	305.5±58.2*	182.0±48.5	235.0±74.7**
1-RM chest press (kg)	26.5±5.7	36.4±4.4**	27.4±6.2	34.5±5.6***	29.2±8.7	35.3±8.0***
Handgrip (kg)	26.1±5.1	26.9±4.5	22.5±3.1†	23.7±3.5†	29.6±4.9	31.5±5.6*
IGF-I (ng/ml)	78.6±51.1	79.5±49.6†††	89.6±38.6	105.8±45.5††	117.8±28.6	219.6±57.9***

Values are mean±s.d. BMI, body mass index; BMR, body mass reduction; GH, growth hormone; NU, nandrolone undecanoate; 1-RM, one repetition-maximum; W, anaerobic power.

Significant difference between pre- and post-treatment values: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$ (paired Student's *t*-test).

Significantly different from the BMR+ GH group: † $P < 0.05$, †† $P < 0.01$, ††† $P < 0.001$ (one-way ANOVA followed by Tukey *post hoc* analysis).

follicle-stimulating hormone (FSH), luteinising hormone (LH) and testosterone (all from DPC, Los Angeles, CA, USA) were determined using commercial kits, before and at the end of the 3-week period. FSH, LH and testosterone concentrations were determined only in the BMR + NU group. Intra-assay coefficients of variation for these parameters were less than 4% and interassay coefficients of variation were less than 7%.

Statistical analyses

For each group, pre- and post-treatment values were compared using a unilateral paired Student's *t*-test. For all the dependent variables, pre- and post-treatment values and percent changes were compared between the three groups using one-way ANOVA followed by Tukey *post hoc* analysis. The level of significance was fixed at $P \leq 0.05$ for all procedures.

Results

Body mass, BMI and fat mass were significantly lower ($P < 0.05$) at the end of the 3-week intervention, whereas fat-free mass did not change significantly whatever the group (Table 1). Post-treatment changes in body composition were comparable between the three experimental groups (Fig. 1A).

Maximal anaerobic power during jumping and maximal strength assessed on the isotonic machines increased significantly ($P < 0.05$) after training (Table 1), but ANOVA showed no significant difference in percentage gains between the three groups (Fig. 1B). Interestingly, handgrip strength did not change significantly after the 3-week period in the BMR group, but a significant increase ($P < 0.05$) was observed for groups BMR + NU and BMR + GH. However, no group effect was observed in relative changes for this variable.

Mean baseline IGF-I concentrations were not significantly different between the three groups (Table 1). No significant changes were found in patients treated with body mass reduction alone (+3.1%), whereas IGF-I increased significantly in patients treated additionally with nandrolone (+19.9%, $P < 0.05$) and rGH (+88.7%, $P < 0.001$). *Post hoc* analysis showed that the relative increase for the latter group (BMR + GH) was significantly greater than that for the two other groups ($P < 0.05$).

Mean FSH, LH and testosterone concentrations were not significantly different in the BMR + NU group before (FSH: 34.3 ± 16.2 IU/l; LH: 12.4 ± 7.4 IU/l; testosterone: 57.7 ± 11.5 ng/dl) and after the treatment (FSH: 38.0 ± 19.9 IU/l; LH: 11.1 ± 6.6 IU/l; testosterone: 63.4 ± 17.3 ng/dl).

No significant side effects were observed during the 3-week period in the three groups.

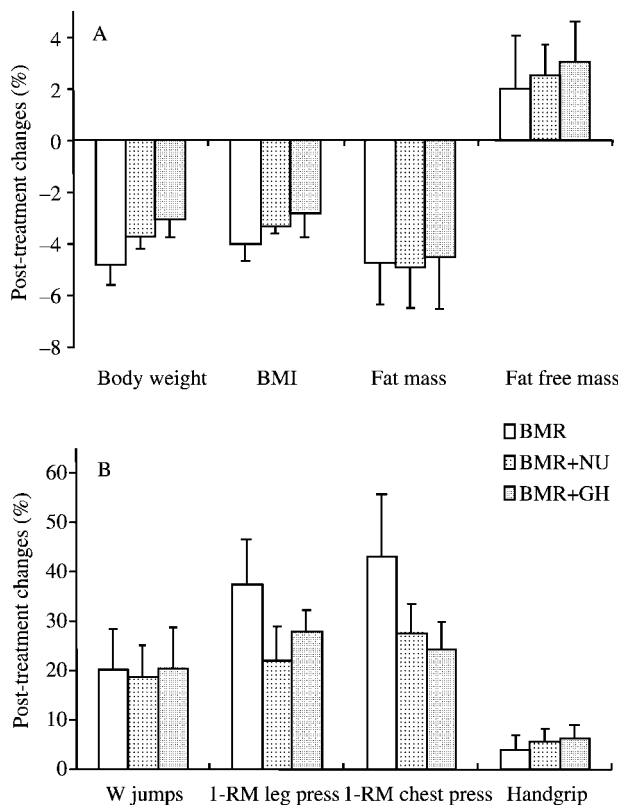


Figure 1 Percent changes between pre- and post-treatment values for the three groups. BMI, body mass index; BMR, body mass reduction; GH, growth hormone; NU, nandrolone undecanoate; 1-RM, one repetition-maximum; W, anaerobic power. Values are mean and S.E.M.

Discussion

The main finding of this study is that the significant reduction in body mass, BMI and fat mass obtained in the three experimental groups at the completion of the 3-week body mass reduction programme was accompanied by a significant increase in the maximal strength and anaerobic power output of the upper and lower limb muscles, which is likely to improve some activities of daily living in elderly severely obese women. An important finding was that fat-free mass was slightly greater (2–3%) in the three experimental groups at the end of the body mass reduction programme, although this was not significant ($P = 0.07$ for the two groups treated pharmacologically), explaining at least in part the improvement in muscle strength and power.

Both rGH and nandrolone undecanoate treatments in association with this body mass reduction programme had beneficial effects on body composition and muscle performance comparable to those of body mass reduction alone, suggesting that the observed adaptations could mainly be ascribed to the energy-restricted diet and to the moderate aerobic-strength physical training. However, it is possible that longer

treatments with greater doses of rGH (and steroids) would exert more evident effects on muscle function than body mass reduction alone, even though they may lead to a greater risk of side effects (8). Bearing in mind the relatively low dosage of nandrolone undecanoate or rGH administered to our patients (80 mg/week and 0.1 IU/kg per week, respectively) and the short duration of the present treatment, we did not observe side effects in severely obese elderly women.

Relative gains in muscle strength after treatment ranged from 22% to 43.1%, and muscle power during consecutive jumps increased approximately 20%, in these elderly females. Interestingly, these changes are very similar to those obtained in our laboratory with young obese individuals who participated in the same body mass reduction programme (12). In the same way, changes in body composition obtained here with females aged 61–75 years were comparable to those previously reported for young obese patients (13). Taken as a whole, these results suggest that the adaptability of body and muscle to a 3-week body mass reduction programme is very similar in both elderly and young severely obese patients, as was also noted by Häkkinen *et al.* (14) to be the case for non-obese individuals. A study is needed to compare accurately the plasticity of body composition and physical performance as a function of age and sex in obese individuals.

The fact that rGH and steroids in association with physical activity and nutritional regimen significantly enhanced the strength of muscular groups not specifically trained (i.e. isometric handgrip), whereas body mass reduction alone had no effect on these groups, is intriguing and requires further investigation, for example in postural muscle groups.

No significant changes in IGF-I concentration were detected in patients treated with energy-restricted diet plus aerobic-strength training, but the addition of rGH was associated with significantly increased IGF-I concentrations (+88.7%), although they remained in the normal range for age in all but one of the women. It is of interest that administration of nandrolone undecanoate also led to significantly increased IGF-I concentrations (+19.9%), although to a lesser extent. Although this latter finding was somewhat surprising, Gayan-Ramirez *et al.* (15) have recently reported that the levels of expression of IGF-I mRNA were increased significantly after a training programme combined with low- or high-dose nandrolone decanoate treatment in rat diaphragm.

In conclusion, the addition of rGH or nandrolone to a 3-week body mass reduction programme combining energy-restricted diet plus moderate aerobic and strength exercise was not more effective than body mass reduction alone in improving body composition and muscle performance in severely obese women aged 61–75 years. Further additional research on a larger study group composed of elderly obese men

and women, and for more prolonged periods of observation, is required to confirm these preliminary observations.

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