CHAPTER 4

RESULTS AND DISCUSSION

The primary aim of this study was to evaluate the effect of an eight-week programme of electrical muscle stimulation (EMS) performed on Slimline Slimming Machines in conjunction with, and without, a thermogenic agent (Thermo Lean) and a standardized diet.

The results of the study are displayed in tabular (Tables 4.1a – 4.8b) and graphic form (Figures 4.1a - 4.8) and are reported in the following categories of dependent variables:

- Anthropometry
- Morphology
- Ultrasound Sonography
- Respiratory Quotient (RQ)
- Pulmonary Function
- Haematology
- Cardiovascular response
- Musculoskeletal Function

Henceforth each variable is presented with respect to responses within and between experimental groups (Tables 4.1a – 4.8b) with the latter also being depicted graphically, as relative differences in Figures 4.1a – 4.8. The variables are further discussed within the context of the relevant literature. It should be emphasized however, that there is a paucity of literature published specifically regarding the efficacy of electrical muscle stimulation (EMS). In this regard only two articles directly linked to this study, and a few indirectly related articles could be located, each publishing varing results.

In an early study, focussing on an obese population, Bailey (1976) conducted an in-depth study of the Hawkins Electrokinetic Body Activating (EBA) Machine to evaluate the safety and effectiveness of the device as a method of localized adipose tissue (fat) reduction and general weight-loss modality. In this trial a group of 40 moderately obese female patients with a mean age of 34-35 years, was selected to serve as subjects. The pre-posttesting battery included measurements of body weight, height, body surface area and appearance (via photographs).

Subjects were given a course of six weeks treatment (3 x one-hour sessions per week) followed by a four-weeks break with no specific instruction. They were then required to attend for a second six-weeks treatment. No attempt was made to regulate the patients diet or exercise during the intermediate four-week period, which was included as a balancing device to lessen any psychological halo effect.

Of the 30 subjects completing the trial, all lost weight in significant amounts (significant at 1% level). Weight-loss ranged from 2.2 kg to 21.5 kg with a mean weight-loss of 7.83 kg. Twenty subjects (50%) lost less than 7.83 kg, but even in this group significant losses were noted in specific tissue regions, such as the "upper arms", the abdomen and particularly the thighs. All patients showed a reduction in body surface area and all showed localized reduction in fat depot areas. There were no reported side effects of treatment, and all subjects expressed satisfaction with the weight and tissue losses achieved.

Abstinence from exercise often results in gradual deterioration in exercise capacity and muscle strength. Electrical muscle stimulation (EMS) is seen as a method of augmenting muscle performance. It has been shown to improve oxidative potential of the muscle (Bigard et al., 1993). Clinical trials in humans have shown that electrical muscle stimulation improve muscle strength and performance in patients with major knee ligament injuries (Wigerstad-Lossing et al., 1988), those who are immobile after surgery (Morrissey et al., 1985), promotes muscle growth in paraplegic patients (Buckley et al., 1987) and improves the performance of ischaemic muscles in patients with peripheral vascular disease (Tsang et al., 1994).

Bourjeily-Habr et al. (2002) noted that although exercise training improves exercise tolerance in most patients with obstructive pulmonary disease, some severely affected patients may be unable to tolerate it because of incapacitating breathlessness. This led the investigators to test whether electrical muscle stimulation of the lower extremities could improve muscle strength and exercise tolerance in patients with moderate to severe chronic obstructive pulmonary disease. The investigator performed electrical muscle stimulation of the lower extremities for 20 minutes three times a week for six weeks in 18 medically stable patients aged 60 ± 1.5 years. The patients were divided into two equal groups who received either genuine or sham treatment. Quadriceps and hamstring muscle strength, exercise capacity and peak oxygen uptake were measured at baseline and at the end of the six weeks of stimulation. It was found that the muscle stimulation improved quadriceps function by 39.0 ± 20.4 percent in the treated patients compared with 9.0 ± 8.1 percent in the sham-treated group. The investigators also found that the muscle stimulation improved hamstring muscle strength by 33.9 ± 13.0 percent in the treated patients compared with 2.9 ± 4.7 percent in the controls. There were no significant changes in lung function, peak workload or peak oxygen consumption in either group.

Poor exercise capacity is also a common manifestation among the obese. The American College of Sports Medicine acknowledges that obese individuals could reap health benefits from exercise without demanding that the exercise meet the traditional intensity requirements suggested for weight-loss (American College of Sports Medicine, 1990). The Surgeon General's Report on Physical Activity and Health declared that physical activity need not be vigorous to improve health (US Department of Health and Human Services, 1996).

In cognisance of the foregoing, this study thus set out to determine whether or not, and to what extent, the advent of electrical muscle stimulation (EMS) could make a significant contribution to help the obese. In a more recent study related to this investigation, Porcari et al. (2002) recruited 27 college-aged volunteers to test the effectiveness of electrical muscle stimulation devices (EMS) on muscle strength, muscle tone, body weight, and body fat in healthy individuals. Volunteers were assigned to either an EMS (n = 16) or control group (n =11). The EMS group underwent electrical muscle stimulation 3 times per week following the manufacturer's recommendations, whereas the control group underwent sham stimulation sessions. The pre- and posttesting battery included measurements of body weight, body fat (via skinfolds), girths, isometric and isokinetic strength and appearance (via photographs from the anterior, side and posterior) EMS had no significant effect on any of the measured parameters. Claims relative to the effectiveness of EMS for the apparently healthy individual are not supported by the findings of this study.

4.1 ANTHROPOMETRY

The results indicating the response of anthropometric variables within and among the experimental groups are reflected in Tables 4.1a – 4.1h and Figures 4.1a – 4.1d.

4.1.1 Body girths

A significant decrease ($p \leq 0,05$) in all body girths was observed within all three groups. A total of ten girth measurements were taken, viz.

	Group EST	Group ESP	Group TS
Forearm	*		
Relaxed arm	*		
Contracted arm		*	
Chest	*		
Mid thigh		*	
Calf	*		
Hip		*	
Abdominal	*		
AB-1 ½ Umbi	*		
AB-2 Umbi		*	

(*Greatest reductions)

Six out of ten girth measurements showed the greatest reduction in group EST (thermogenic and electrical muscle stimulation following a standardized diet). The remaining girth measures had the greatest reduction in group ESP (electrical muscle stimulation, following a standardized diet and placebo controlled). There were no girth measures where group TS (thermogenic stimulation following a standardized diet) showed the greatest reduction.

If girths at all ten body sites were summed, group EST (thermogenic and electrical muscle stimulation following a standardized diet) had the greatest reduction (5.11%), followed by group ESP (electrical muscle stimulation, following a standardized diet and placebo controlled) with a reduction of 4.74% and then group TS (thermogenic stimulation following a standardized diet) with a 4.05% reduction. The greatest decrease in the sum of body girths was observed in group EST but this decrease was not significantly greater ($p>0,05$) than decreases found in group ESP or group TS (Figure 4.16 and Table 4.1c & d). The same tendency that was found in the reduction in the sum of body girths was found in the reduction of body mass, body mass index, waist-to-hip ratio and body surface area between the three experimental groups. In all of the above mentioned variables group EST (thermogenic and electrical stimulation following a standardized diet) had the greatest reductions followed by group ESP (electrical muscle stimulation following a standardized diet and placebo controlled) and group TS (thermogenic stimulation following a standardized diet). The combination of diet, thermogenic and electrical muscle stimulation was the more successful intervention program because of the negative caloric balance created by the diet, enhanced metabolic rate as a result of the thermogenic agent and a combination of a negative caloric balance and enhanced metabolic rate induced by the electrical muscle stimulation.

There was a statistically significant difference between groups ($p\leq0,05$) in the reduction of body girths at three different body sites viz. abdominal, abdominal (AB-1), abdominal AB-2).

Coincidentally these three body sites included sites utilized for determing the relative body fat according to the technique of Weltman et al. (1988). Weight-loss is associated with a significant reduction in abdominal subcutaneous and visceral fat and the reduction in visceral fat is related to corresponding reduction in metabolic risk factors. The greater the weight-loss, the greater the reduction in abdominal fat (Ross, 1997). Accordingly reductions in body girths of the abdominal region were of great importance for this study. A reduction in abdominal body girths meant a reduction in percent body fat and this may relate to a reduction in metabolic risk factors.

Group EST (6.02%) had the greatest reduction in girth at the abdominal body site. This reduction was significantly ($p\leq0,05$) better than the reduction found in group ESP (4.79%) and group TS (4.69%).

Table 4.1a: Anthropometry : Body Girth Responses. Intra-Group Comparisons (NS =p > 0,05; ∗ p ≤ 0,05)

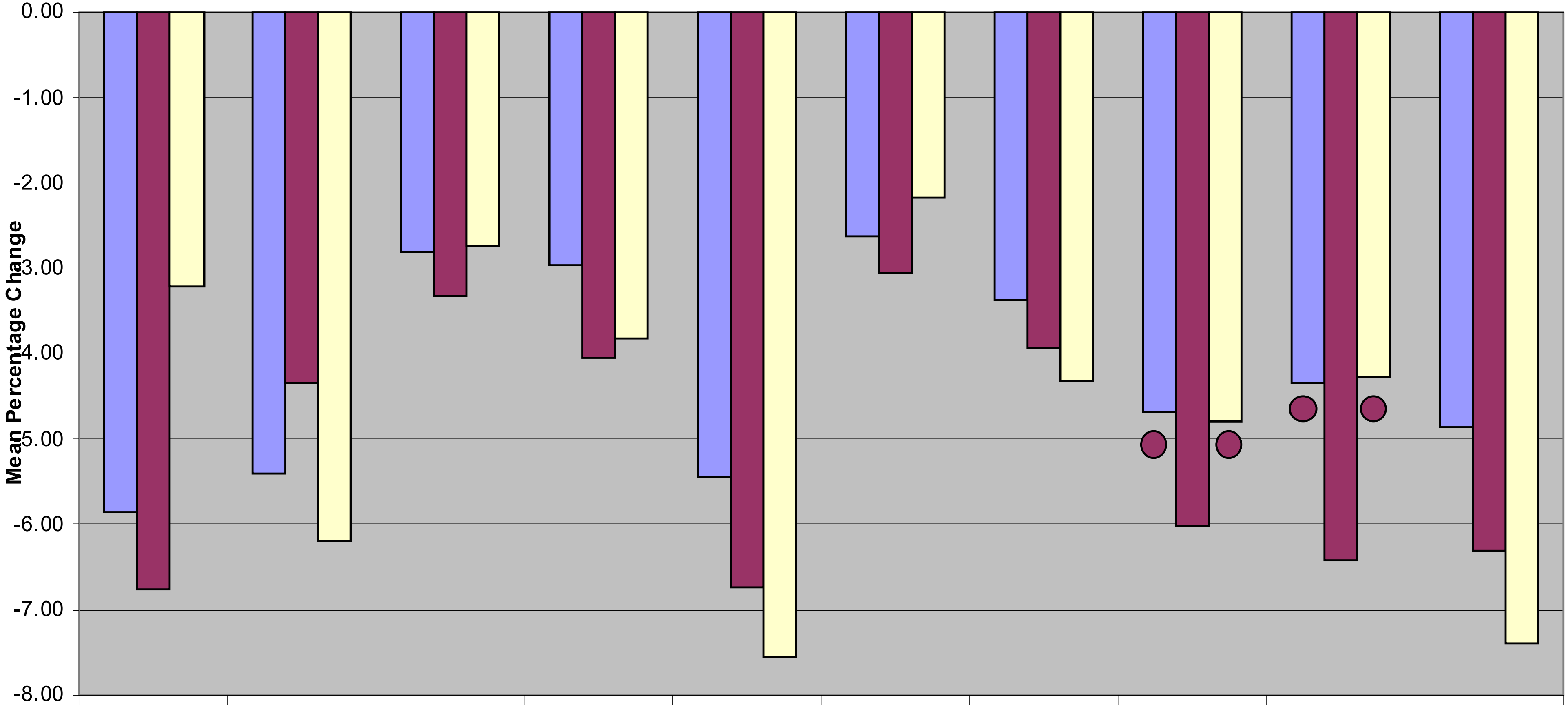
Groups		TS (n=20)						EST (n=20)						ESP (n=22)					
VARIABLES	UNITS	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p
Relaxed Arm	cm	35.48	6.12	33.40	5.69	-2.08	∗	33.37	4.61	31.11	3.66	-2.26	∗	34.56	5.31	33.45	4.99	-1.11	∗
Contracted Arm	cm	38.37	6.27	36.30	5.75	-2.07	∗	35.04	5.17	33.52	4.08	-1.52	∗	37.83	5.37	35.49	4.97	-2.34	∗
Forearm	cm	28.90	3.05	28.09	2.92	-0.81	∗	27.44	2.48	26.53	2.28	-0.91	∗	28.79	2.51	28.00	2.39	-0.79	∗
Chest	cm	112.63	13.48	109.29	13.84	-3.34	∗	108.68	8.88	104.27	8.15	-4.41	∗	115.09	13.18	110.70	11.54	-4.39	∗
Mid Thigh	cm	70.89	7.88	67.03	8.04	-3.86	∗	65.85	8.37	61.41	6.29	-4.44	∗	69.90	10.67	64.35	10.11	-5.25	∗
Calf	cm	42.53	4.35	41.41	4.07	-1.12	∗	40.13	4.54	38.90	4.03	-1.23	∗	42.73	5.17	41.80	5.15	-0.93	∗
Hip	cm	122.80	15.30	118.65	15.25	-4.15	∗	116.33	10.95	111.74	8.64	-4.59	∗	126.39	15.80	120.94	15.07	-5.45	∗
Abdominal	cm	97.03	14.35	92.48	14.21	-4.55	∗	91.50	10.35	85.99	8.02	-5.51	∗	99.63	15.39	94.86	13.71	-4.77	∗
AB–1 ½Umbi	cm	96.48	14.57	92.28	13.99	-4.20	∗	82.52	9.82	86.58	8.01	-5.94	∗	101.74	16.34	97.36	15.46	-4.35	∗
AB-2 Umbi	cm	106.95	20.89	101.76	20.59	-5.19	∗	101.32	13.81	94.93	10.35	-6.39	∗	114.08	18.64	105.65	14.94	-8.43	∗

Group TS ---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).

Table 4.1b: Anthropometry : Body Girth Responses . Inter-Group Comparisons **(NS =p > 0,05; ● p ≤ 0,05)**

Groups		TS	EST	ESP	Significance		
VARIABLES		%Δ	%Δ	%Δ	TS vs EST	TS vs ESP	EST vs ESP
Relaxed Arm	cm	-5.68	-6.77	-3.21	NS	NS	NS
Contracted Arm	cm	-5.39	-4.34	-6.19	NS	NS	NS
Forearm	cm	-2.80	-3.32	-2.74	NS	NS	NS
Chest	cm	-2.97	-4.06	-3.81	NS	NS	NS
Mid Thigh	cm	-5.45	-6.74	-7.54	NS	NS	NS
Calf	cm	-2.63	-3.07	-2.18	NS	NS	NS
Hip	cm	-3.38	-3.95	-4.31	NS	NS	NS
Abdominal	cm	-4.69	-6.02	-4.79	●	NS	●
AB–1 ½Umbi	cm	-4.35	-6.42	-4.28	●	NS	●
AB-2 Umbi	cm	-4.85	-6.31	-7.39	NS	NS	NS

Group TS---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).



	Relaxed Arm	Contracted Arm	Forearm	Chest	Mid Thigh	Calf	Hip	Abdominal	AB-1 ½Umbi	AB-2 Umbi
TS	-5.86	-5.39	-2.80	-2.97	-5.45	-2.63	-3.38	-4.69	-4.35	-4.85
EST	-6.77	-4.34	-3.32	-4.06	-6.74	-3.07	-3.95	-6.02	-6.42	-6.31
ESP	-3.21	-6.19	-2.74	-3.81	-7.54	-2.18	-4.31	-4.79	-4.28	-7.39

Figure 4.1a: Anthropometry : Body Girth Responses between Groups

Table 4.1c: Anthropometry : Sum of Body Girths Response. Intra-Group Comparisons (NS =p > 0.05; ✳ p ≤ 0.05)

Groups		TS (n=20)						EST (n=20)						ESP (n=22)					
VARIABLES	UNITS	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p
Girths	cm	794.63	99.91	762.41	98.45	-32.22	✳	754.11	69.79	715.54	53.11	-38.57	✳	813.17	100.25	774.63	90.30	-38.54	✳

Table 4.1d: Anthropometry : Sum of Body Girths Response. Inter-Group Comparisons (NS =p > 0,05; ● p ≤ 0,05)

Groups		TS	EST	ESP	Significance		
VARIABLES		%Δ	%Δ	%Δ	TS vs EST	TS vs ESP	EST vs ESP
Girths	cm	-4.05	-5.11	-4.74	NS	NS	NS

Group TS ---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).

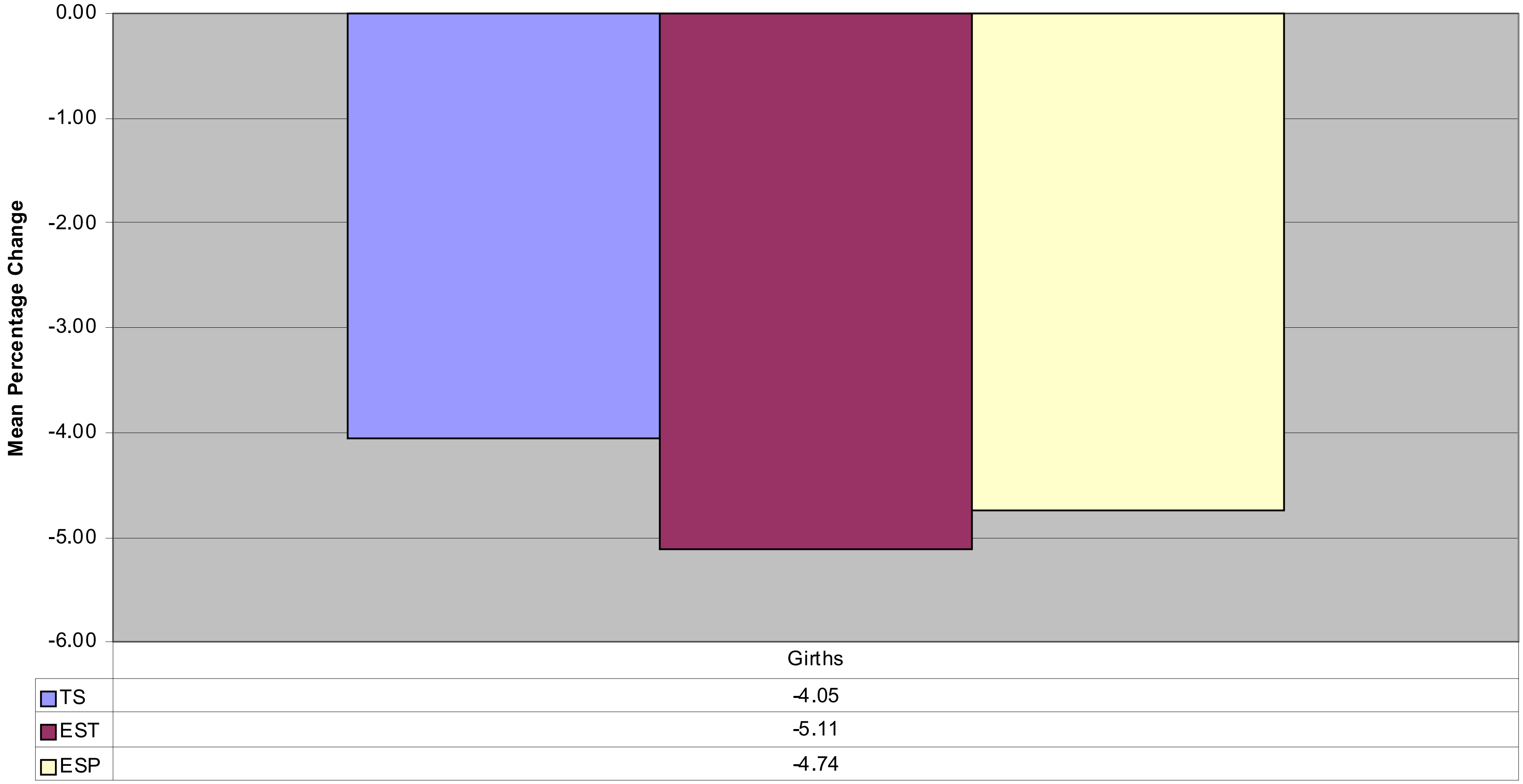


Figure 4.1b: Anthropometry : Sum of Body Girths Response between Groups

The same tendency was found at the abdominal AB-1 body site. Group EST (6.42%) had the greatest reduction in girth at the abdominal AB-1 body site. This reduction was significantly (p≤0,05) better than the reduction found in group TS (4.35%) and group ESP (4.28%).

Group ESP had the greatest reduction in girth at the umbilicus level (7.39%). This reduction was significantly (p≤0,05) better than the reduction found in group TS (4.85%) but not significantly (p>0,05) better than the reduction found in group EST (6.31%). Interventions with EMS (electrical muscle stimulation) did better at the abdominal body sites than those without.

The biggest reduction in specific body girth measurements was found at the mid-thigh body site. Group ESP (7.54%) had the greatest reduction, but this was not significantly (p>0,05) better than reductions found in group EST (6.74%) or group TS (5.45%), at the same site.

4.1.2 Skinfolds

A significant (p≤0,05) reduction in all skinfold measurements were observed within the three experimental groups. A total of seven skinfold measurements were taken, viz.

	Group EST	**Group ESP**	**Group TS**
Triceps	*		
Subscapular	*		
Suprailiac			*
Biceps	*		
Calf			
Abdominal			
Mid-thigh			*

(*Greatest reductions)

Table 4.1e: Anthropometry : Skinfold Responses. Intra-Group Comparisons (NS =p > 0,05; ✳ p ≤ 0,05)

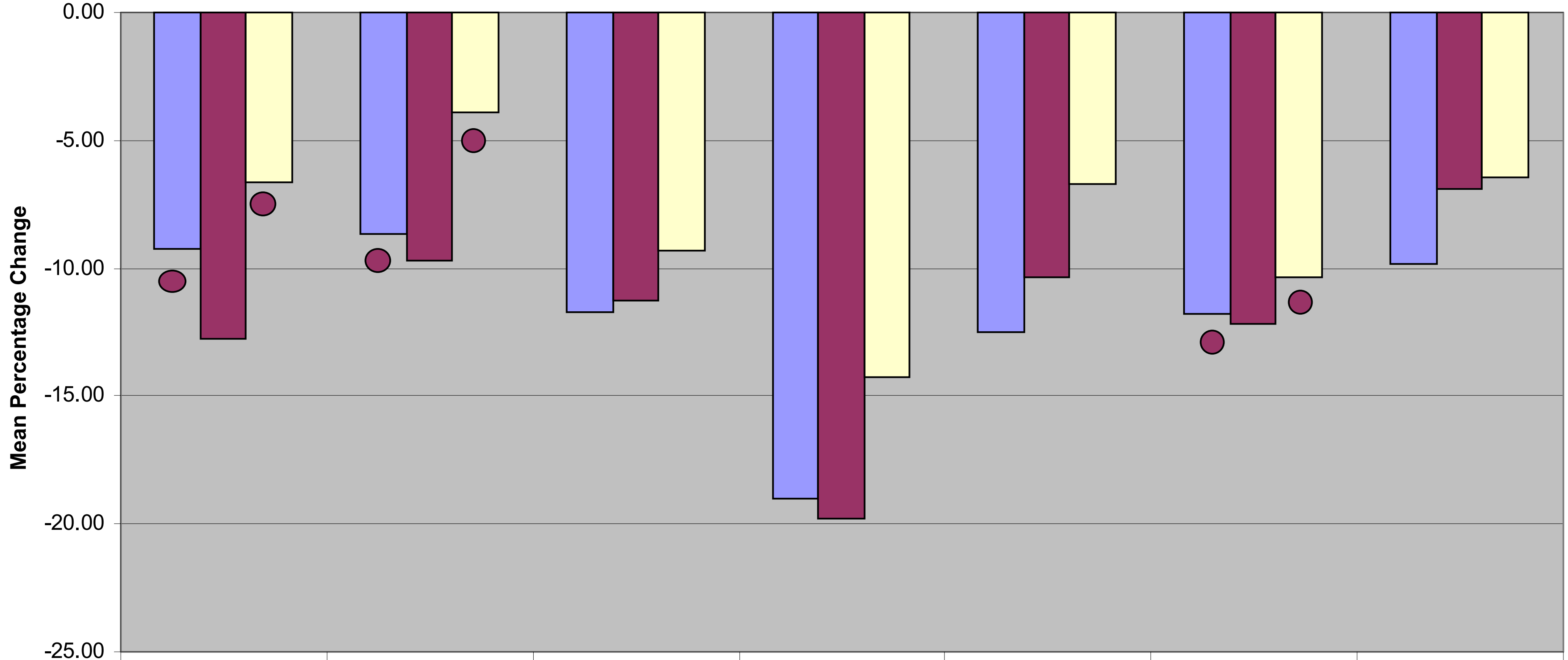
Groups		TS (n=20)						EST (n=20)						ESP (n=22)					
VARIABLES	UNITS	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p
Triceps	mm	34.29	9.06	31.11	8.75	-3.18	✳	30.35	11.59	26.48	7.46	-3.87	✳	37.12	11.28	34.66	10.59	-2.46	✳
Subscapular	mm	37.95	11.51	34.67	11.40	-3.28	✳	32.07	7.22	28.96	5.94	-3.11	✳	37.65	12.08	36.17	12.23	-1.48	✳
Suprailiac	mm	38.99	10.80	34.43	10.88	-4.56	✳	33.33	8.78	29.57	7.75	-3.76	✳	39.43	10.57	35.77	10.23	-3.66	✳
Biceps	mm	24.60	9.00	19.93	9.03	-4.67	✳	23.78	6.56	19.07	5.35	-4.71	✳	23.97	7.89	20.56	7.56	-3.41	✳
Calf	mm	34.00	12.16	29.75	11.83	-4.25	✳	32.83	9.22	29.43	7.93	-3.40	✳	39.25	10.93	36.61	12.37	-2.64	✳
Abdominal	mm	43.14	8.69	38.05	10.11	-5.09	✳	40.27	10.34	35.38	8.96	-4.89	✳	47.41	11.04	42.50	11.08	-4.91	✳
Mid-Thigh	mm	50.19	8.88	45.26	9.86	-4.93	✳	47.42	12.48	44.14	9.73	-3.28	✳	49.44	9.59	46.25	10.67	-3.19	✳

Group TS ---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).

Table 4.1f: Anthropometry : Skinfold Responses. Inter-Group Comparisons **(NS =p > 0,05; ● p ≤ 0,05)**

Groups		TS	EST	ESP	Significance		
VARIABLES		%Δ	%Δ	%Δ	TS vs EST	TS vs ESP	EST vs ESP
Triceps	mm	-9.27	-12.75	-6.63	●	NS	●
Subscapular	mm	-8.64	-9.70	-3.93	●	NS	●
Suprailiac	mm	-11.70	-11.28	-9.28	NS	NS	NS
Biceps	mm	-18.98	-19.81	-14.23	NS	NS	NS
Calf	mm	-12.50	-10.36	-6.73	NS	NS	NS
Abdominal	mm	-11.80	-12.14	-10.36	●	NS	●
Mid-Thigh	mm	-9.82	-6.92	-6.45	NS	NS	NS

Group TS---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).



	Triceps	Subscapular	Suprailiac	Biceps	Calf	Abdominal	Mid-thigh
TS	-9.27	-8.64	-11.70	-18.98	-12.50	-11.80	-9.82
EST	-12.75	-9.70	-11.28	-19.81	-10.36	-12.14	-6.92
ESP	-6.63	-3.93	-9.28	-14.23	-6.73	-10.36	-6.45

Figure 4.1c: Anthropometry : Skinfold Responses between Groups

In four out of seven skinfold measurements the greatest reduction was found in group EST (thermogenic and electrical muscle stimulation following a standardized diet). At the remaining three body sites group TS (thermogenic stimulation following a standardized diet) showed the greatest reduction. There were no body sites where group ESP (electrical muscle stimulation, following a standardized diet and placebo controlled) had the greatest reduction. The combination of diet, thermogenic and electrical muscle stimulation was the more successful intervention program when considering the skinfold response among groups.

There was a significant difference ($p \leq 0,05$) between groups in the reduction in skinfolds at three sites viz. triceps, sub-scapula, abdominal.

The greatest statistically significant difference ($p \leq 0,05$) in the reduction of skinfold measurements between groups was found at the tricep body site. Group EST had the greatest reduction (12.75%). This reduction was significantly ($p \leq 0,05$) better than the reduction found in both groups TS (9.27%) and ESP (6.63%).

The second greatest statistically significant difference ($p \leq 0,05$) in the reduction of skinfold measurementsbetween groups was found at the abdominal body site. Once again group EST had the greatest reduction (12.14%). This reduction was significantly ($p \leq 0,05$) better than the reduction found in both groups TS (11.80%) and ESP (10.36%).

The third greatest statistically significant difference ($p \leq 0,05$) in the reduction of skinfold measurements between groups was found at the subscapular body site. Again group EST had the greatest reduction (9.70%). This reduction was significantly ($p \leq 0,05$) better than the reduction found in both groups TS (8.64%) and ESP (3.93%).

The greatest reduction in all seven skinfolds that were measured was at the bicep site. Group EST had the greatest reduction (19.81%) followed by group TS (18.98%) and then group ESP (14.23%). None of these decreases between groups were significant ($p > 0,05$) however.

The observed significantly ($p \leq 0,05$) greater reduction in skinfold measurement at the abdominal body site in group EST is in accordance with a significantly ($p \leq 0,05$) greater reduction in girth measurements at the abdominal body sites in the same group. One of the most profound problem areas in all obese woman is the abdomen. The combination of diet, thermogenic and electrical muscle stimulation had the greatest effect in the reduction in skinfolds as well as girths in this problematic body area.

A number of investigators have tested the accuracy of population-specific (Durnin & Womersley, 1974) and generalized (Jackson & Pollock, 1978; Jackson et al., 1980) skinfold equations in overweight and obese samples. Overall, it appears that the SKF method have limited applicability to obese individuals.

The applicability of skinfolds methods in obese individuals is limited for the following reasons:

1. Site selection and palpation of bony landmarks are more difficult in obese individuals (Bray & Gray, 1988).

2. The skinfold thickness may be larger than the jaw aperture of most callipers, and it may not be possible to lift the skinfold from the underlying tissue in some obese clients (Gray et al., 1990).

3. There is greater variation in the depth at which the calliper tips can be placed on the SKF, and the calliper tips may slide on larger skinfolds (Bray & Gray, 1988).

4. Variability in adipose tissue composition may affect skinfolds compressibility in obese clients (Clarys et al., 1987).

5. There is greater variability among testers when measuring larger skinfold thickness (Bray & Gray, 1988).

4.1.3 Saggital height

Two saggital height measurements were made:

i) Saggital ½ umbi: The spirit level of the anthropometer was placed on the abdomen halfway between the xyphoid process and the umbilicus.

ii) Saggital umbi: The spirit level was placed on the umbilicus.

A significant ($p \leq 0,05$) decrease in saggital height measurements was observed within all three experimental groups at both body sites (saggital ½ umbi and saggital umbi). At the umbilicus body site (saggital umbi) group ESP (11.48%) had the greatest reduction. This reduction was similar to the reduction found in group EST (11.02%) but did not differ significantly ($p > 0,05$) from the reduction found in group TS (8.59%). At the saggital ½ umbi body site, group EST (13.52%) had the greatest reduction in saggital height. This reduction was significantly ($p \leq 0,05$) greater than that found in both groups ESP (10.61%) and TS (10.60%).

This significantly ($p \leq 0,05$) greater reduction in saggital height at the saggital ½ umbi body site in group EST, corresponds with the significant ($p \leq 0,05$) decreases found in body girths and skinfolds in the same group. Diet, thermogenic and electrical muscle stimulation (Group EST) thus had the greatest effect on the reduction in saggital height, skinfolds and girths at these problematic abdominal body sites.

The impact of regional fat distribution on health is related to the amount of visceral fat located within the abdominal cavity. The proliferation of research on body fat distribution and its relationship to disease has expanded at an exponential rate over the past 10 years, providing clear evidence that a link exists between increased abdominal fat and increased morbidity and mortality (Després, 1991). This research demonstrate strong associations between abdominal fat and diseases such as coronary artery disease (Donahue et al., 1987), diabetes (Björntorp, 1988), hypertension (Blair et al., 1984; White et al., 1986) and hyperlipidemia (Blair et al., 1984; Després et al., 1987).

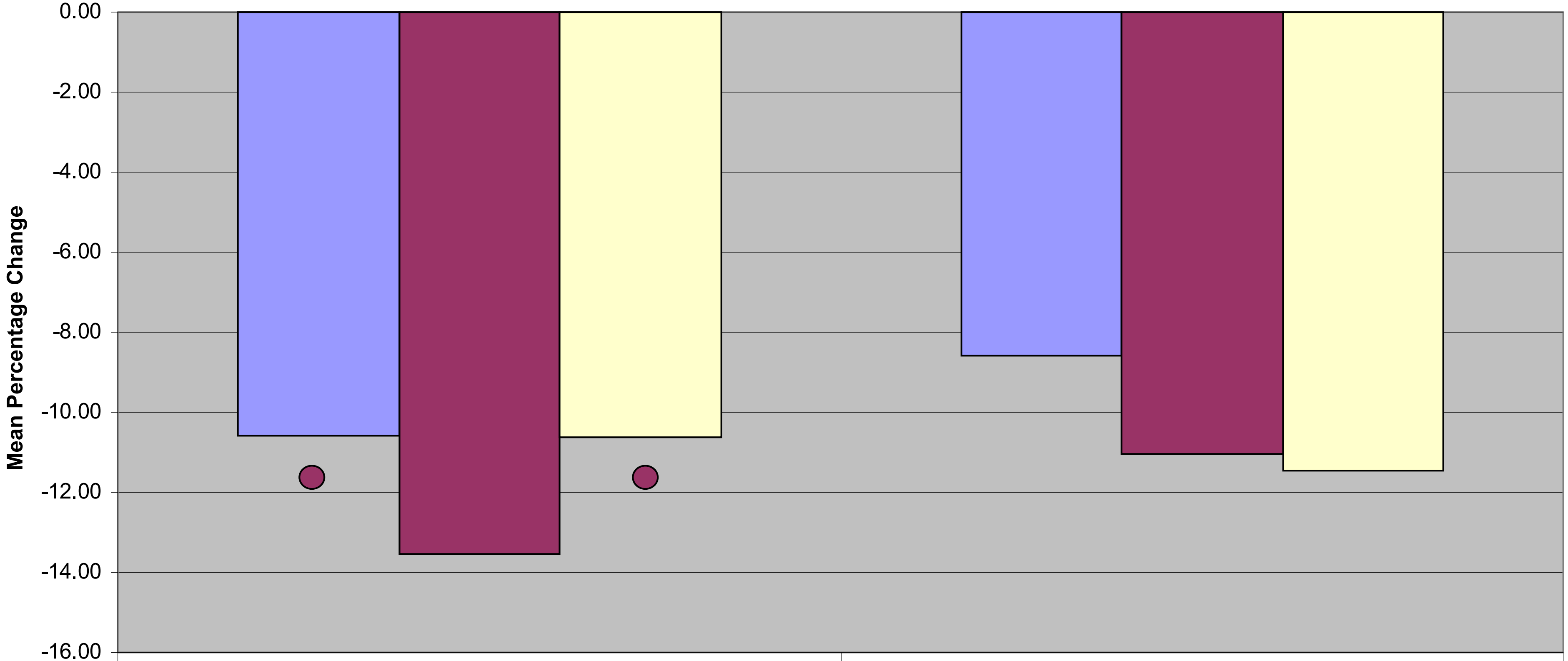
Table 4.1g: Anthropometry : Saggital Height Responses. Intra-Group Comparisons (NS =p > 0.05; ∗ p ≤ 0.05)

Groups		TS (n=20)						EST (n=20)						ESP (n=22)					
VARIABLES	UNITS	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p
Saggital ½Umbi	cm	24.34	4.54	21.76	4.57	-2.58	∗	22.63	2.88	19.57	1.62	-3.06	∗	24.50	3.89	21.90	3.69	-2.60	∗
Saggital Umbi	cm	22.46	4.29	20.53	3.76	-1.93	∗	21.59	3.26	19.2	1.88	-2.38	∗	24.05	4.06	21.29	3.79	-2.76	∗

Table 4.1h: Anthropometry : Saggital Height Responses. Inter-Group Comparisons (NS =p > 0,05; ● p ≤ 0,05)

Groups		TS	EST	ESP	Significance		
VARIABLES		%Δ	%Δ	%Δ	TS vs EST	TS vs ESP	EST vs ESP
Saggital ½Umbi	cm	-10.60	-13.50	-10.61	●	NS	●
Saggital Umbi	cm	-8.59	-11.00	-11.48	NS	NS	NS

Group TS ---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).



	Saggital ½Umbi	Saggital Umbi
TS	-10.60	-8.59
EST	-13.52	-11.02
ESP	-10.61	-11.48

Figure 4.1d: Anthropometry : Saggital Height Responses between Groups

Anthropmetric indices can be used to classify individuals according to their type of obesity, such as upper body or abdominal obesity (high-risk) or lower-body obesity (low-risk). Numerous anthropometric measures are significantly related to intra-abdominal fat, viz. skinfold measure of the trunk (umbilicus, suprailiac, subscapular), waist and hip circumferences, the ratio of the waist-to-hip circumference (WHR), and body mass index (BMI). There are only two anthropometric indixes, BMI and WHR that are widely recognized for their ability to predict disease risk. These two indices have existing norms and standards for classifying individuals into high- or low-risk categories (Björntorp, 1993; Ciba Foundation, 1996).

If a positive correlation can be established between supine saggital abdominal height and visceral sonography (absolute measurement of intra-abdominal fat) then a link between increased saggital diameters and increased morbidity and mortality could be inferred among obese females.

4.2 MORPHOLOGY

The results indicating the response of morphological variables among the experimental groups are reflected in Tables 4.2a – 4.2f and Figures 4.2a – 4.2c.

4.2.1 Body mass

A significant ($p \leq 0,05$) decrease in body mass was observed within all three groups. The largest (6.43%) reduction in body mass was seen in those subjects on both thermogenic and electrical muscle stimulation following a standardized diet (Group EST) but this was not significantly greater ($p > 0,05$) than in those on thermogenic stimulation and following a standardized diet (Group TS = 5.72%) or those on electrical muscle stimulation and following a standardized diet (placebo controlled) (Group ESP = 5.10%).

Body mass is not the most accurate method of measuring the change in body composition. Factors like water retention, menstruation, increase in lean body mass, and many more, can produce fluctuations in body mass (Plowman & Smith, 1997).

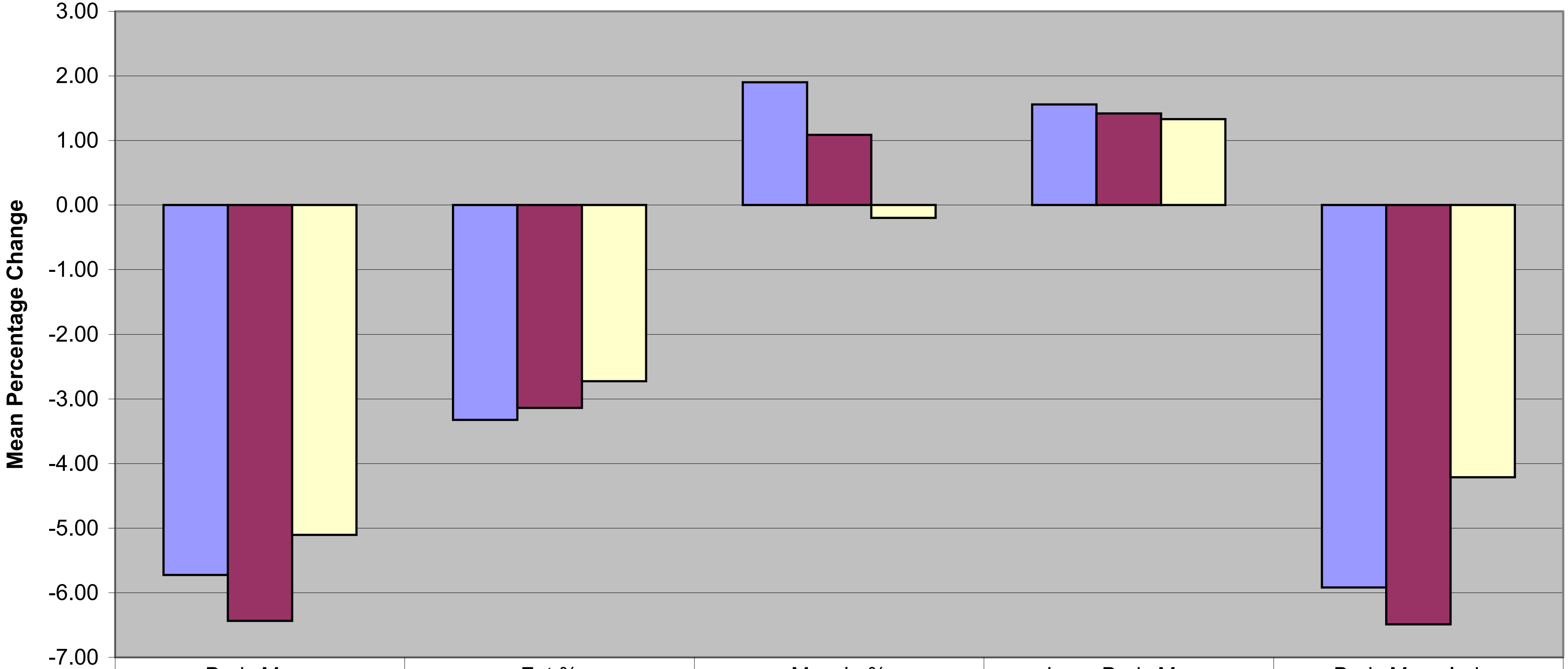
Table 4.2a: Morphological Responses. Intra-Group Comparisons (NS =p > 0,05; ✳ p ≤ 0,05)

Groups		TS (n=20)						EST (n=20)						ESP (n=22)					
VARIABLES	UNITS	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p
Body Mass	kg	98.53	22.13	92.89	20.41	-5.64	✳	89.99	17.00	84.20	13.94	-5.79	✳	100.12	24.08	95.01	23.16	-5.11	✳
Fat %	%	46.91	4.82	45.35	4.49	-1.56	✳	45.26	2.77	43.84	2.27	-1.42	✳	48.04	4.43	46.73	4.41	-1.31	✳
Muscle %	%	32.11	3.17	32.72	3.72	0.61	NS	32.24	2.87	32.59	2.65	0.35	NS	30.76	2.96	30.70	3.84	-0.06	NS
Lean Body Mass	%	53.09	4.82	45.65	4.49	1.56	✳	54.74	2.77	56.15	2.27	1.42	✳	51.68	4.55	53.01	4.55	1.33	✳
Body Mass Index	kg/m²	35.49	7.51	33.39	7.49	-2.10	✳	32.53	5.13	30.42	3.89	-2.11	✳	36.32	7.02	34.79	7.54	-1.53	✳

Table 4.2b: Morphological Responses. Inter-Group Comparisons (NS =p > 0,05; ● p ≤ 0,05)

Groups		TS	EST	ESP	Significance		
VARIABLES		%Δ	%Δ	%Δ	TS vs EST	TS vs ESP	EST vs ESP
Body Mass	kg	-5.72	-6.43	-5.10	NS	NS	NS
Fat %	%	-3.33	-3.14	-2.73	NS	NS	NS
Muscle %	%	1.90	1.09	-0.20	NS	NS	NS
Lean Body Mass	%	1.56	1.42	1.33	NS	NS	NS
Body Mass Index	kg/m²	-5.92	-6.49	-4.21	NS	NS	NS

Group TS ---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).



	Body Mass	Fat %	Muscle %	Lean Body Mass	Body Mass Index
TS	-5.72	-3.33	1.90	1.56	-5.92
EST	-6.43	-3.14	1.09	1.42	-6.49
ESP	-5.10	-2.73	-0.20	1.33	-4.21

Figure 4.2a: Morphological Responses between Groups

The negative caloric balance created through diet plus thermogenic stimulation (Group TS), diet plus thermogenic and electrical muscle stimulation (Group EST) or diet plus electrical muscle stimulation, placebo controlled (Group) all significantly contributed to a reduction in body mass.

The combination of diet, thermogenic and electrical muscle stimulation (Group EST) tended to be the more successful intervention program because of the negative caloric balance induced by the diet, and the enhanced metabolic rate as a result of the thermogenic agent and electrical muscle stimulation combined.

4.2.2 Percentage body fat (BF)

A significant ($p \leq 0,05$) decrease in percentage body fat was observed within all three groups. Group TS (3.33%) and group EST's (3.14%) reduction in percentage body fat were the highest but not significantly ($p>0,05$) greater than the other modality, ESP (2.73%). The previously observed reduction in absolute body mass in groups TS, EST and ESP can thus be ascribed to the reduction of body fat in these groups.

The negative caloric balance created through diet plus a thermogenic agent (Group TS), diet plus thermogenic and electrical muscle stimulation (Group EST) or diet plus electrical muscle stimulation, placebo controlled (Group ESP) significantly contributed to the reduction in percentage body fat.

4.2.3 Percentage muscle

No significant ($p>0,05$) changes were observed within groups. The greatest increase in percentage muscle was found in group TS (1.90%) followed by group EST (1.09%). None of these two increases were significantly greater ($p>0,05$) than the reduction found in group ESP (-0.20%).

There were an inverted correlation between percentage muscle gained and percentage fat loss in all three groups. Group TS had the highest percentage fat loss (3.33%) and the greatest gain in muscle percentage (1.90%) followed by group EST with a 3.14% fat loss and a 1.09% gain in muscle percentage. Group ESP had the lowest percentage of fat loss (2.73%) and a loss in muscle mass (-0.20%).

4.2.4 Lean body mass

An increase in lean body mass (LBM) was observed in all three groups. The greatest (1.56%) increase in lean body mass, was seen in those subjects on thermogenic stimulation following a standardized diet (Group TS) but this was not significantly greater (p>0,05) than those on both thermogenic and electrical muscle stimulation following a standardized diet (Group EST = 1.42%) or those on electrical muscle stimulation following a standardized diet, placebo controlled (Group ESP = 1.33%)

Lean body mass was calculated as an anthropometric variable of body composition. The previously observed reduction in absolute body mass and fat percentage in groups TS, EST and ESP can thus be ascribed to the increase in lean body mass in all three groups. The negative caloric balanced created through diet plus a thermogenic agent (Group TS), diet plus thermogenic and electrical muscle stimulation (Group EST) or diet plus electrical muscle stimulation, placebo controlled (Group ESP) significantly contributed to the increase in lean body mass.

4.2.5 Body mass index

A significantly reduced ($p \leq 0,05$) BMI was observed within all groups. As in the case of the related decrease in body mass the greatest reduction in BMI was in group EST (6.49%) but this reduction was not significantly (p>0,05) better than in group TS (5.92%) or group ESP (4.21%). The negative caloric balance created through diet plus the increase in metabolism created by the thermogenic agent in conjunction with the electrical muscle stimulation (exercise) had the greatest effect on the reduction of BMI (Group EST).

4.2.6 Waist-to-hip ratio

A significantly reduced ($p \leq 0,05$) waist-to-hip ratio (WHR) was observed within two of the three experimental groups. The greatest reduction was found in group EST (2.53%) and this reduction was significantly ($p \leq 0,05$) better than the reduction found in group TS (1.27%) and group ESP (1.27%).

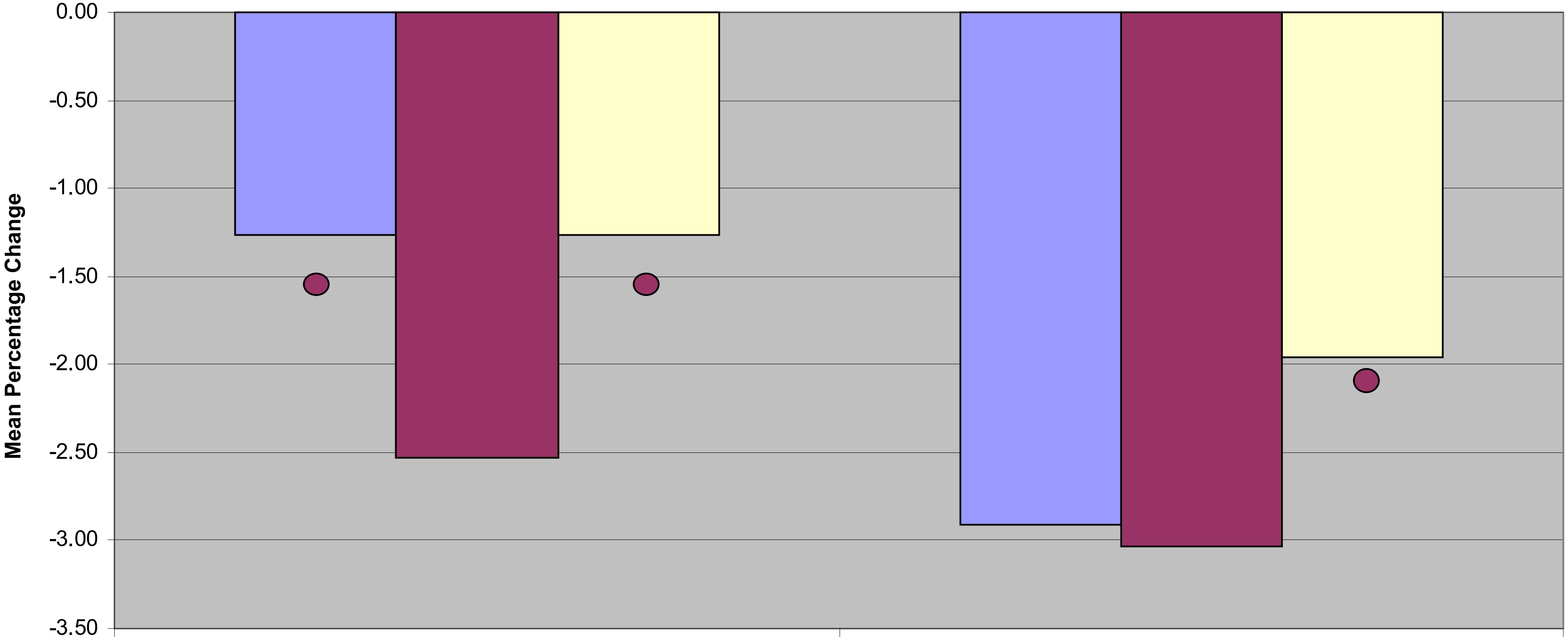
Table 4.2c: Waist-to-Hip Ratio and Body Surface Area Responses. Intra-Group Comparisons (NS =p > 0.05; ✳ p ≤ 0.05)

Groups		TS (n=20)						EST (n=20)						ESP (n=22)					
VARIABLES	UNITS	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p
Waist-to-Hip Ratio	N/A	0.79	0.06	0.78	0.06	-0.01	✳	0.79	0.06	0.77	0.06	-0.02	✳	0.79	0.07	0.78	0.06	-0.01	NS
Body Surface Area	m²	2.06	0.19	2.00	0.19	-0.06	✳	1.98	0.19	1.92	0.18	-0.06	✳	2.04	0.22	2.00	0.24	-0.04	✳

Table 4.2d: Waist-to-Hip Ratio and Body Surface Area Responses. Inter-Group Comparisons (NS =p > 0,05; ● p ≤ 0,05)

Groups		TS	EST	ESP	Significance		
VARIABLES		%Δ	%Δ	%Δ	TS vs EST	TS vs ESP	EST vs ESP
Waist-to-Hip Ratio	N/A	-1.27	-2.53	-1.27	●	NS	●
Body Surface Area	m²	-2.91	-3.03	-1.96	NS	NS	●

Group TS ---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).



	Waist-to-Hip Ratio	Body Surface Area
TS	-1.27	-2.91
EST	-2.53	-3.03
ESP	-1.27	-1.96

Figure 4.2b: Waist-to-Hip Ratio and Body Surface Area Responses between Groups

The statistically significant reduction ($p \leq 0,05$) found in group EST (2.53%) indicates that a combination of diet, electrical muscle stimulation and a thermogenic agent had the greatest effect on WHR. WHR is strongly associated with visceral fat (Ashwell et al., 1985; Seidell et al., 1987) and appears to be an acceptable index of intra-abdominal fat (Jakicic, 1993). Certain predictions about health-related comorbidities can be made by using WHR (Van Itallie, 1985). Although an abdominal fat distribution was proposed as a health hazard for coronary heart disease in the 1940's for the first time, it took a long time before it was confirmed (Després et al., 1995). Confirmation only came when various studies showed that a simple anthropometric measurement such as the waist-to-hip ratio (WHR) correlated with insulin resistance, hyperinsulinaemia, dyslipidaemia, hypertension and CHD (Després et al., 1990; Gillum, 1987; Lapidus et al., 1984). A study on females undergoing coronary angiography, showed that the pattern of their body fat distribution not only correlated with metabolic and hormonal cardiovascular risk factors, but that those with major coronary stenoses in fact had a significantly higher WHR than a healthy control group (Hauner et al., 1994). These observations suggest that strategies designed to reduce obesity would be enhanced if abdominal obesity, in particular visceral fat, was substantially reduced. It is well established that diet-induced weight-loss is associated with a significant reduction in abdominal subcutaneous and visceral fat and that reduction in visceral fat is related to a corresponding reduction in metabolic risk factors. The greater the diet-induced weight-loss, the greater the reduction in abdominal fat, with a 10% weight-loss corresponding to a 30 to 35% reduction in visceral fat (Ross, 1997).

Few studies have examined whether exercise-induced weight-loss is associated with concomitant reduction in abdominal subcutaneous and/or visceral fat. Using waist circumference as a surrogate measure of abdominal obesity, it is reported that minor reductions (2 cm) in waist circumference are observed in response to exercise-induced weight-loss in the order of 2 to 3 kg (Ross et al., 2000).

No other studies have examined the influence of a combination of diet, electrical muscle stimulation and thermogenic stimulation on weight-loss and especially abdominal fat loss. In this study it is reasonable to conclude that a combination of diet, electrical muscle stimulation and thermogenic stimulation led to a decrease in waist-to-hip ratio and could have positive effects on certain health aspects.

4.2.7 Body surface area

A significant decrease ($p \leq 0,05$) in body surface area (BSA) was observed within all three groups. The largest (3.03%) reduction in BSA was seen in those subjects on both thermogenic and electrical muscle stimulation following a standardized diet (Group EST) and this reduction was significantly greater ($p \leq 0,05$) than the group on electrical muscle stimulation following a standardized diet, placebo controlled (Group ESP = 1.96%). There was no significant difference between group EST (3.03%) and group TS (2.91%). The combination of a standardized diet and the thermogenic agent (Group TS = 2.91%) had a far greater effect albeit statistically insignificant ($p > 0,05$) on body surface area reduction than a standardized diet and electrical muscle stimulation (Group ESP = 1.96%).

4.2.8 Somatotype

Somatotype deals with the body type or physical classification of the human body. The terms endomorph, mesomorph, and ectomorph are used to describe a person in terms of his or her somatotype.

The results indicating somatotype responses among the experimental groups are reflected in Table 4.2e & f and Figure 4.2c.

4.2.8.1 <u>Endomorphy (Somatotype I)</u>

The first component (somatotype I) is endomorphy and is characterized by roundness and softness of the body. In ordinary language, endomorphy is the "fatness" component of the body. A reduction in this component was of importance in this study. Significant decreases ($p \leq 0,05$) were observed in all three groups. The largest (6.98%) reduction in the endomorph component was seen in those subjects on both thermogenic and electrical muscle stimulation following a standardized diet (Group EST) but this was not significantly greater ($p > 0,05$) than those on a thermogenic stimulation and following a standardized diet (Group TS = 6.94%) or those on electrical muscle stimulation and following a standardized diet, placebo controlled (Group ESP = 3.97%). Group EST (6.98%) and group TS (6.94%) had a similar percentage reduction in somatotype I (endomorphy). This shows the superiority of interventions with a thermogenic agent following a standardized diet (Groups EST and TS) over group ESP with only electrical muscle stimulation and following a standardized diet. This reduction found in somatotype I (fatness component) correlates with the reduction found earlier with body mass and percentage body fat in all three study groups.

All of the subjects included in this study were of endomorphic build. Features of this build are a predominance of abdomen over thorax, high square shoulders, and short neck. There is a smoothness of contours throughout, with no muscle relief.

4.2.8.2 Mesomorphy (Somatotype II)

The second component is mesomorphy (somatotype II) and is characterized by a square body with hard, rugged and prominent musculation. The bones are large and covered with thick muscles. Legs, trunks, and arms are usually massive in bone and heavily muscled throughout. Outstanding characteristics of this type are forearm thickness and heavy wrists, hands and fingers. The thorax is large and the waist is relatively slender.

In ordinary language mesomorphy is the “muscle” component of the body. It was suspected that a decrease in the endomorphic component could have led to a decrease in the mesomorph component as well. A decrease in skinfold and increase in girth measurements usually results in the increase in somatotype II (mesomorph).

A significant decrease ($p \leq 0,05$) in somatotype II (mesomorphy) was observed within all three groups. The reduction in somatotype II (mesomorphy) was similar in all three the groups with group EST (6.97%) followed by group ESP (6.53%) and then group TS (6.14%). The electrical muscle stimulation (Group EST and ESP) had no increased effect on somatotype II (mesomorphy) and this raises the question if it can be used as and substitute for active training.

4.2.8.3 Ectomorphy (Somatotype III)

The third component ectomorphy (somatotype III) includes as predominant characteristics linearity, fragility, and delicacy of body. The bones are small and th

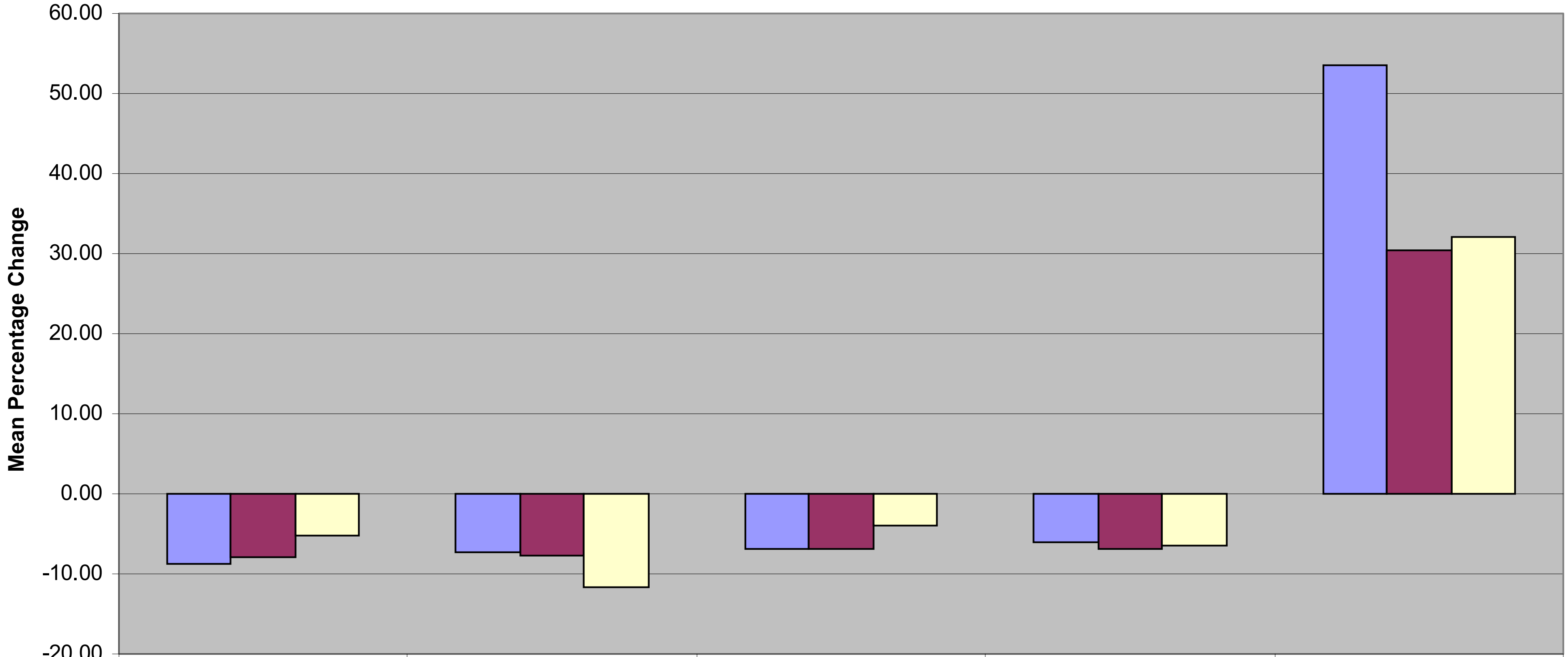
Table 4.2e: Somatotype Responses. Intra-Group Comparisons (NS =p > 0,05; ∗ p ≤ 0,05)

Groups		TS (n=20)						EST (n=20)						ESP (n=22)					
VARIABLES	UNITS	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p
Somatotype X	N/A	-8.53	1.49	-7.79	2.06	-0.74	∗	-7.80	1.44	-7.19	1.21	-0.61	∗	-8.66	1.75	-8.2	2.09	-0.45	∗
Somatotype Y	N/A	6.87	4.58	6.37	4.35	0.50	∗	5.17	2.80	4.77	2.79	-0.40	∗	6.17	3.69	5.45	3.56	-0.72	∗
Endomorph	N/A	8.93	1.24	8.31	1.52	-0.62	∗	8.17	1.24	7.60	1.02	-0.57	∗	9.07	1.49	8.71	1.65	-0.36	∗
Mesomorph	N/A	7.98	2.58	7.49	2.46	-0.49	∗	6.74	1.65	6.27	1.47	-0.47	∗	7.66	2.24	7.16	2.15	-0.50	∗
Ectomorph	N/A	0.28	0.45	0.43	0.72	0.15	∗	0.23	0.24	0.30	0.28	0.07	∗	0.25	0.38	0.33	0.57	0.08	∗

Table 4.2f: Somatotype Responses. Inter-Group Comparisons (NS =p > 0,05; ● p ≤ 0,05)

Groups		TS	EST	ESP	Significance		
VARIABLES		%Δ	%Δ	%Δ	TS vs EST	TS vs ESP	EST vs ESP
Somatotype X	N/A	-8.68	-7.82	-5.2	NS	NS	NS
Somatotype Y	N/A	-7.28	-7.14	-6.98	NS	NS	NS
Endomorph	N/A	-6.94	-6.98	-3.97	NS	NS	NS
Mesomorph	N/A	-6.14	-6.97	-6.53	NS	NS	NS
Ectomorph	N/A	53.57	30.43	32.00	NS	NS	NS

Group TS ---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).



	Somatotype X	Somatotype Y	Endomorph	Mesomorph	Ectomorph
TS	-8.68	-7.28	-6.94	-6.14	53.57
EST	-7.82	-7.74	-6.98	-6.97	30.43
ESP	-5.20	-11.67	-3.97	-6.53	32.00

Figure 4.2c: Somatotype Responses between Groups

muscles thin. This is the "leanness" component. All subjects used in this study (BMI ≥ 30) were directly placed in the extreme opposite of this somatotype III (ectomorphy). A reduction in the "fatness" component would have meant an increase in the "leanness" component.

A significant increase ($p \leq 0,05$) in somatotype III (ectomorphy) was observed in all experimental groups. The greatest increase in somatotype III (ectomorphy) was found in group TS (53.57%) followed by groups ESP and EST with similar percentage increases (Group ESP = 32.00% and Group EST = 30.43%). Although the greatest increase was observed in group TS (thermogenic stimulation following a standardized diet) this increase was not significantly greater ($p > 0,05$) than increases found in group ESP (electrical muscle stimulation following a standardized diet, placebo controlled) or group EST (thermogenic and electrical muscle stimulation following a standardized diet). This increase in somatotype III (ectomorphy) correlates with the percentage increase in muscle mass found in group TS. The largest increase in percentage muscle (Group TS = 1.90%) and the greatest decrease in percentage fat (Group TS = 3.33%) lead to the biggest difference in somatotype III (Group TS = 53.57%).

4.2.8.4 Somatogram

A somatogram was used as an anthropometric profile that graphically depicts the subjects pattern of muscle and fat distribution. Somatograms were especially useful for charting changes (pre- and post-test profiles) and monitoring progress of subjects involved in this weight-loss study. Somatotyping has also been used to describe the type of physique that was most susceptible to various diseases. The Heath-Carter anthropometric somatogram comprising of an x and y-axis was used to graphically depict subjects in each experimental group. The pre-test (x) and post-test (✔) positions of each group are displayed on the somatogram (Appendix C).

4.2.8.4a Somatogram (x-axis)

All three experimental groups had significantly decreased ($p \leq 0,05$) x-axis values. The largest reduction on the x-axis value was found in group TS (8.68%) followed by group EST (7.82%) and group ESP (5.20%). None of these decreases between groups were significant ($p>0,05$).

4.2.8.4b Somatogram (y-axis)

A significantly decrease ($p\leq0,05$) value on the y-axis was observed within all experimental groups. The largest reduction (11.67%) in value on the y-axis was seen in those subjects on electrical muscle stimulation following a standardized diet (placebo controlled) in group ESP, but this was not significantly greater ($p>0,05$) than those on both thermogenic and electrical muscle stimulation following a standardized diet (Group EST = 7.74%) or those on thermogenic stimulation following a standardized diet (Group TS = 7.28%).

4.3 ULTRASOUND SONOGRAPHY

The results indicating the response of ultrasound sonographic variables among the experimental groups are reflected in Table 4.3a & b and Figure 4.3.

Two sonographic measurements were taken:

i) Subcutaneous fat layer: Measured from the skin surface to the M. rectus abdominus; and

ii) Visceral fat layer: Measured from the M. rectus abdominus to the anterior wall of the aorta.

A significant ($p\leq0,05$) decrease in sonographic measurements was found within all three experimental groups at both subcutaneous as well as visceral fat layers. The subcutaneous fat layer in group EST (21.22%) showed the greatest reduction. This reduction was significantly ($p\leq0,05$) greater than the reduction in subcutaneous fat found in both groups TS (18.04%) and ESP (12.11%).

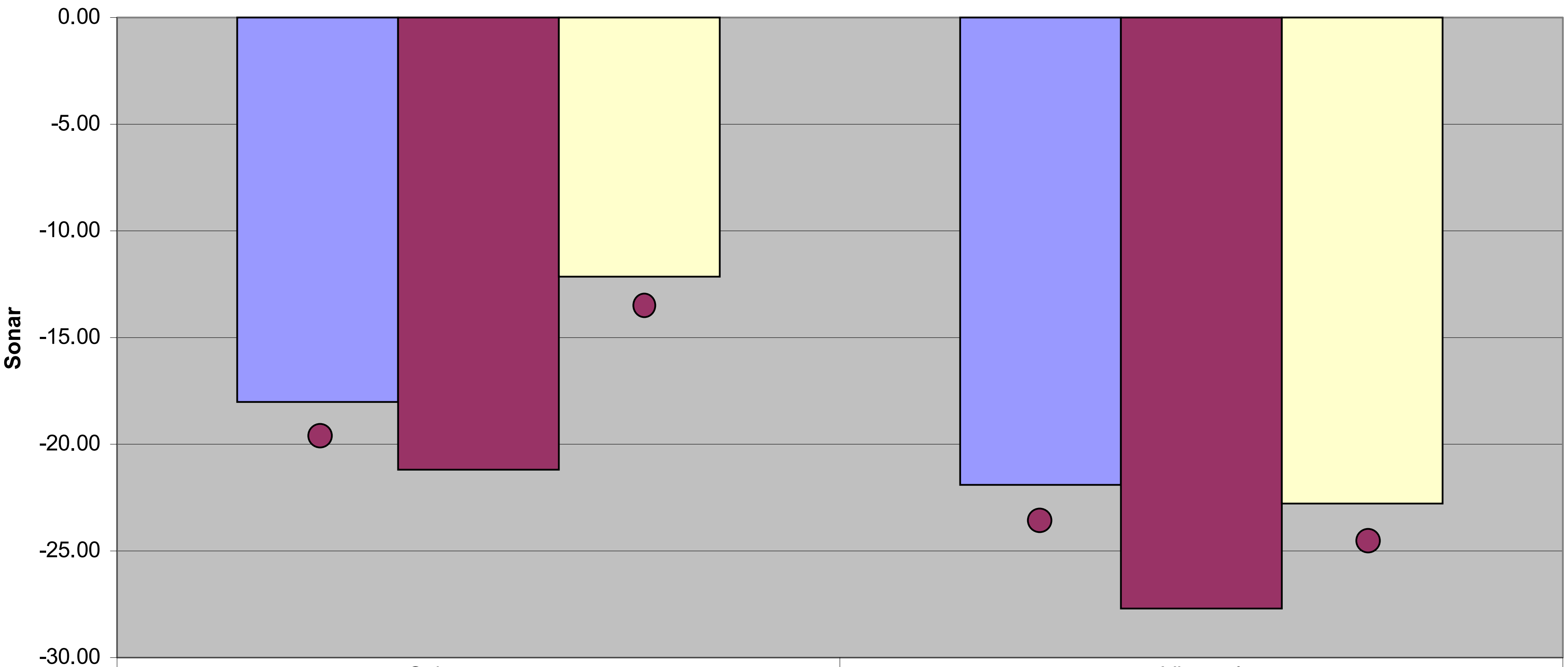
Table 4.3a: Ultrasound Sonography Responses. Intra-Group Comparisons (NS =p > 0.05; ∗ p ≤ 0.05)

Groups		TS (n=20)						EST (n=20)						ESP (n=22)					
VARIABLES	UNITS	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p
Subcutaneous	mm	32.31	8.58	26.48	9.04	-5.83	∗	27.24	9.61	21.46	7.09	-5.78	∗	33.02	9.64	29.02	10.72	-4.00	∗
Visceral	mm	58.86	25.14	45.99	23.13	-12.87	∗	59.92	22.27	43.30	15.14	-16.62	∗	62.19	14.13	48.00	73.00	-14.19	∗

Table 4.3b: Ultrasound Sonography Responses. Inter-Group Comparisons (NS =p > 0,05; ● p ≤ 0,05)

Groups		TS	EST	ESP	Significance		
VARIABLES		%Δ	%Δ	%Δ	TS vs EST	TS vs ESP	EST vs ESP
Subcutaneous	mm	-18.04	-21.22	-12.11	●	NS	●
Visceral	mm	-21.87	-27.74	-22.82	●	NS	●

Group TS ---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).



	Subcutaneous	Visceral
TS	-18.04	-21.87
EST	-21.22	-27.74
ESP	-12.11	-22.82

Figure 4.3: Ultrasound Sonography Responses between Groups

The visceral fat layer in group EST (27.74%) also showed the greatest reduction among the three experimental groups. This reduction was significantly ($p \leq 0,05$) greater than that found in both groups ESP (22.82%) and TS (21.87%).

This significantly ($p \leq 0,05$) greater reduction in subcutaneous and visceral fat found in group EST, corresponds with the significant ($p \leq 0,05$) decreases found in body girths, skinfolds and saggital height at the abdominal body site in the same group. Thus for the best reduction in subcutaneous and visceral fat in the abdominal area a combination of diet, thermogenic and electrical muscle stimulation (Group EST) was the most effective.

Group TS (thermogenic stimulation and following a standardized diet) had the second largest reduction in subcutaneous fat (18.04%). This reduction was however not significantly ($p > 0,05$) greater than the reduction found in group ESP (electrical muscle stimulation following a standardized diet and placebo controlled) with a 12.11% reduction. The combination of diet and thermogenic stimulation (Group TS) however did show a tangible effect on the reduction in subcutaneous fat in the abdominal region and may be a usefull modality for obese females.

Visceral abdominal obesity is damaging to health. It has a strong link to "syndrome X" the deadly quartet of high insulin, high sugar, high cholesterol, and high blood pressure (Després, 1991). Even in people who don't have these problems, abdominal obesity is clearly associated with high levels of detrimental LDL cholesterol and low levels of protective HDL cholesterol. Abdominal (visceral) obesity is strongly linked to an increased risk of heart disease and stroke and is far more hazardous to health than subcutaneous obesity. Gender is the most powerful influence on the distribution of body fat, but it's not the only factor. Genetics is responsible for up to 70 percent of an individual's tendency to accumulate extra weight in the midsection (subcutaneous and visceral fat). Age, however, is most responsible for abdominal obesity (Després, 1991).

Abdominal obesity frequently coexist with general overweight or obesity but it could be present in the absence of general onverweight. The presence of abdominal obesity aggravates the deleterious effects arising from general overweight/obesity alone.

The gold standard to determine the presence and extent of intra-abdominal fat (visceral) is with imaging procedures (sonographic measurements). However, as it is so costly to measure intra-abdominal obesity, until now very little data has existed on the impact of exercise, electrical muscle stimulation, thermogenic stimulation and diet on this dangerous, hidden health risk. The advantage of thermogenic and electrical muscle stimulation following a standardized diet (Group EST) as a method to reduce total and intra-abdominal fat, and therefore chronic disease, is that it can be done by most women at affordable cost and with minor risk of side effects.

4.4 RESPIRATORY QUOTIENT

The results indicating the response of respiratory quotient (RQ) when testing in the supine position among the experimental groups are reflected in Table 4.4a & b and Figure 4.4.

A significant ($p \leq 0,05$) decrease in RQ was observed within all groups. The greatest decrease in RQ was observed in group ESP (14.04%). This decrease in RQ in group ESP (electrical muscle stimulation following a standardized diet, placebo controlled) was not significantly ($p > 0,05$) greater than the decreases found in group TS (thermogenic stimulation following a standardized diet = 11.61%) or group EST (thermogenic and electrical muscle stimulation following a standardized diet = 9.35%).

In all intra-group comparisons the significant ($p \leq 0.05$) reduction in pre- post test RQ values indicated a shift from the metabolic substrate carbohydrate to the metabolic substrate of fat. This could be ascribed to all three experimental groups following the same diet. When the metabolic substrate is purely carbohydrate, then the RQ value is 1.0+. When the metabolic substrate is predominantly fat, the RQ approaches 0.7 (Plowman & Smith, 1997).

4.5 PULMONARY FUNCTION

The results indicating the pulmonary function variables among the experimental groups are reflected in Table 4.5a & b and Figure 4.5. An improvement in lung function was observed to a smaller or larger extent within all groups.

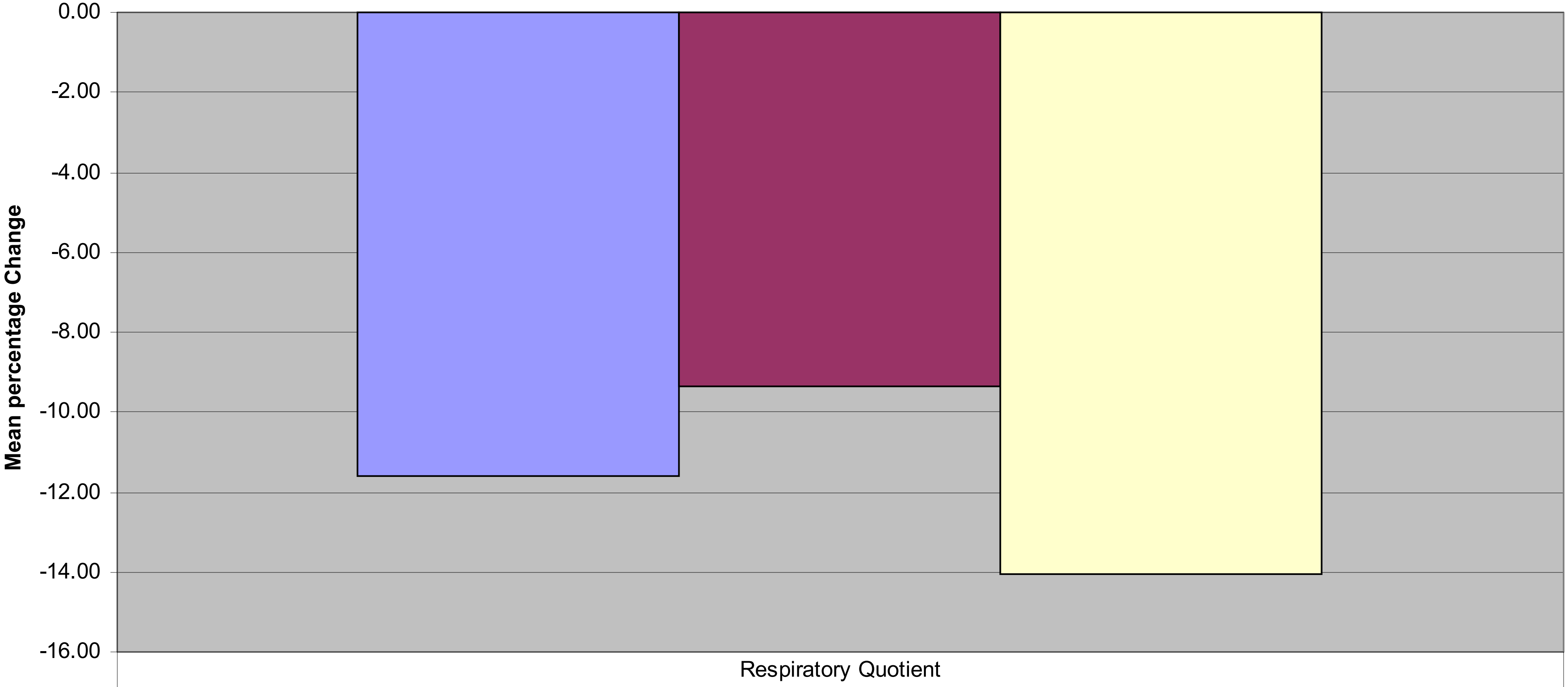
Table 4.4a: Respiratory Quotient Response. Intra-Group Comparisons (NS =p > 0.05; ∗ p ≤ 0.05)

Groups		TS (n=20)						EST (n=20)						ESP (n=22)					
VARIABLES	UNITS	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p
RQ	N/A	1.12	0.22	0.99	2.13	-0.13	∗	1.07	0.15	0.97	0.13	-0.10	∗	1.14	0.29	0.98	0.19	-0.16	∗

Table 4.4b: Respiratory Quotient Response. Inter-Group Comparisons (NS =p > 0,05; ● p ≤ 0,05)

Groups		TS	EST	ESP	Significance		
VARIABLES		%Δ	%Δ	%Δ	TS vs EST	TS vs ESP	EST vs ESP
RQ	N/A	-11.61	-9.35	-14.04	NS	NS	NS

Group TS ---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).



	Respiratory Quotient
TS	-11.61
EST	-9.35
ESP	-14.04

Figure 4.4: Respiratory Quotient Response between Groups

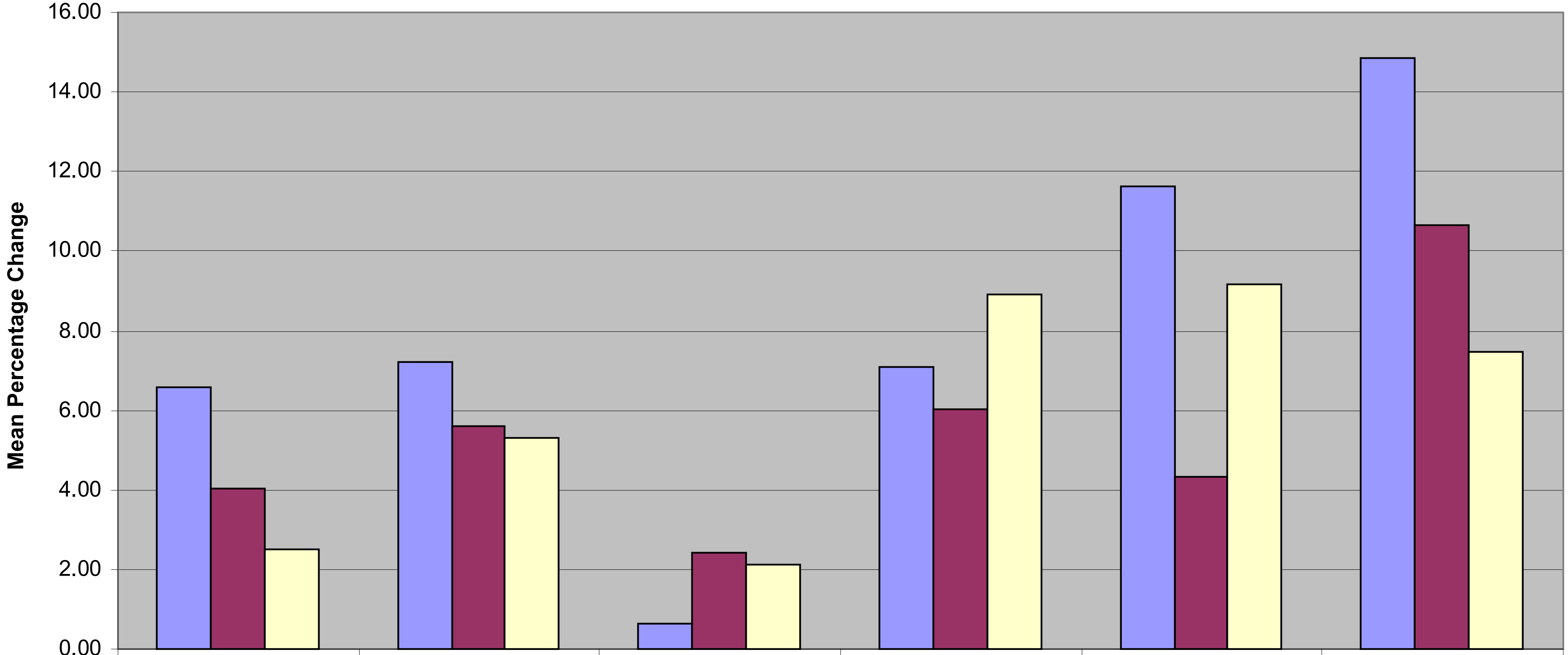
Table 4.5a: Pulmonary Function Responses. Intra-Group Comparisons (NS =p > 0,05; ∗ p ≤ 0,05)

Groups		TS (n=20)						EST (n=20)						ESP (n=22)					
VARIABLES	UNITS	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	P
FVC	L	3.64	0.46	3.88	0.64	0.24	∗	3.46	0.51	3.60	0.50	0.14	∗	3.61	0.75	3.70	0.77	0.09	NS
FEV 1.0	L	3.05	0.40	3.27	0.60	0.22	∗	2.86	0.43	3.02	0.40	0.16	∗	3.01	0.55	3.17	0.62	0.16	∗
FEV 1%	%	83.90	4.62	84.45	4.91	0.55	NS	82.70	5.07	84.70	4.30	2.00	∗	83.86	4.91	85.64	4.10	1.78	∗
PEF	L/sec	6.34	0.95	6.79	1.11	0.45	∗	6.13	0.98	6.50	1.03	0.37	NS	6.06	1.06	6.60	1.33	0.54	∗
MEF 50%	L/sec	3.78	0.75	4.22	1.23	0.44	∗	3.70	0.94	3.86	0.94	0.16	NS	3.71	0.70	4.05	0.82	0.34	∗
MEF 25%	L/sec	1.55	0.00	1.78	0.56	0.23	∗	1.14	0.46	1.56	0.35	0.15	∗	1.61	0.50	1.73	0.47	0.12	∗

Table 4.5b: Pulmonary Function Responses. Inter-Group Comparisons (NS =p > 0,05; ● p ≤ 0,05)

Groups		TS	EST	ESP	Significance		
VARIABLES		%Δ	%Δ	%Δ	TS vs EST	TS vs ESP	EST vs ESP
FVC	L	6.59	4.05	2.49	NS	NS	NS
FEV 1.0	L	7.21	5.59	5.32	NS	NS	NS
FEV 1%	%	0.66	2.42	2.12	NS	NS	NS
PEF	L/sec	7.10	6.04	8.91	NS	NS	NS
MEF 50%	L/sec	11.64	4.32	9.16	NS	NS	NS
MEF 25%	L/sec	14.84	10.64	7.45	NS	NS	NS

Group TS---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).



	FVC	FEV 1.0	FEV 1%	PEF	MEF 50%	MEF 25%
TS	6.59	7.21	0.66	7.10	11.64	14.84
EST	4.05	5.59	2.42	6.04	4.32	10.64
ESP	2.49	5.32	2.12	8.91	9.16	7.45

Figure 4.5: Pulmonary Function Responses between Groups

The greatest and significant ($p \leq 0,05$) increase in forced vital capacity (FVC) was observed in group TS (6.59%). This increase in FVC in group TS (thermogenic stimulation following a standardized diet) was however not significant ($p > 0,05$) greater than the significant ($p \leq 0,05$) increase found in group EST (thermogenic and electrical muscle stimulation following a standardized diet = 4.05%) or the non-significant ($p > 0,05$) increase within group ESP (electrical muscle stimulation following a standardized diet, and placebo controlled = 2.49%).

The greatest and significant ($p \leq 0,05$) increase in forced expiratory volume during the 1^{st} second of forced vital capacity (FEV_1) was also found in group TS. This increase in FEV_1 in group TS (7.21%) was, however not significantly ($p > 0,05$) greater than the equally significant ($p \leq 0,05$) increases found within groups EST (5.59%) and group ESP (5.32%).

The greatest and significant ($p \leq 0,05$) increase in $FEV_1\%$, thus indicating breathing efficiency, was observed in group EST (2.42%). This increase in $FEV_1\%$ observed in group EST was not significantly ($p > 0,05$) greater than the significant ($p \leq 0,05$) increase found within group ESP (2.12%) or the non-significant ($p > 0,05$) increase within group TS (0.66%).

An increased amount of fat in the chest wall and diaphragm leads to an alteration of respiratory excursion during inspiration and expiration. The increase mass of fat leads to a decrease in the compliance of the respiratory system as a whole with a greater reduction being seen in the chest wall rather than the lungs. This mass loading increases both the elasticity and inertia of the respiratory system and requires an increased respiratory muscle force to overcome the excessive elastic recoil and an associated increase in the elastic work of breathing (Kopelman, 1984). If the increase amount of fat leads to the above mentioned, the decrease of fat should lead to an increase in $FEV_1\%$ (breathing efficiency).

The greatest reduction in body mass, lean body mass, body mass index, waist-to-hip ratio, body surface area, sum of body girths, sum of seven skinfolds, saggital height and abdominal sonography measurements were found in group EST and thus corresponds positively with the increase found in $FEV_1\%$ (breathing efficiency).

The greatest and significant ($p \leq 0,05$) increase in peak expiratory flow (PEF) was observed within group ESP (8.91%). This increase in PEF in group ESP was not significantly ($p > 0,05$) different from the significant ($p \leq 0,05$) increase found in group TS (7.10%) or the insignificant ($p > 0,05$) increases within group EST (6.04%). Peak expiratory flow is an indication of the involvement of the respiratory muscles. Exercise, especially abdominal exercise, seems to improve expiration force. This is an indication that it is not only obesity that causes mechanical abnormalities, but also a deficiency in respiratory strength (Babb, 1999). If abdominal exercise improves expiration force, the potential influence of electrical muscle stimulation (EMS) was observed in group ESP (8.91%) and group EST (6.04%) both with an increase in PEF values.

The greatest and significant ($p \leq 0,05$) increase in mid-flow (MEF 50%) was observed in group TS (11.64%). This increase in MEF 50% in group TS did not differ significantly ($p > 0,05$) from the equally significant ($p \leq 0,05$) increases found in group ESP (9.16%) and group EST (4.32%). The same tendency was observed in end-flow (MEF 25%) with the greatest and significant ($p \leq 0,05$) increase observed in group TS (14.84%). This increase in MEF 25% in group TS did not differ significantly ($p > 0,05$) from the equally significant ($p \leq 0,05$)increases found in group EST (10.64%) and group ESP (7.45%).

In four out of the six pulmonary function parameters that were tested, group TS (thermogenic stimulation following a standardized diet) showed the greatest increase. Subjects in all three experimental groups showed signs of restricted pulmonary ventilation, especially in the bronchial tubes (MEF 25%). Ventilation-perfusion is the most common abnormality of gas exchange found in extreme obesity (Kopelman, 1984). Although there were significant ($p \leq 0,05$) increases in MEF 25% values in the pre-post test values within each group, there were no significant differences ($p > 0,05$) between groups after the eight weeks on the respective intervention programs. These results do, however, support findings from other studies (Babb et al., 1989) that weight-loss results in a mechanical improvement in respiration among obese people.

Investigators at Yale University in the United States, noted that although exercise training improves exercise tolerance in most patients with chronic obstructive pulmonary disease, some severely affected patients may be unable to tolerate it because of incapacitating breathlessness (Bourjeily-Habr et al., 2002). There were no significant changes in lung function, peak workload or peak oxygen consumption in either group (Bourjeily-Habr et al., 2002).

4.6 HAEMATOLOGY

Obesity is associated with metabolic abnormalities such as abnormal cholesterol and triglyceride levels, impaired glucose and insulin metabolism and increased blood pressure. The results indicating the response of haematological variables among the experimental groups are reflected in Tables 4.6a & b and Figure 4.6.

4.6.1 Total cholesterol

The only reduction in total cholesterol was seen in group TS (0.58%). The reduction found in group TS (thermogenic stimulation following an standardized diet) did not differ significantly ($p>0.05$) from the increases found in group EST (4.48%) and group ESP (3.61%). Thermogenic stimulation following a standardized diet (Group TS) was thus no more effective in alternating total cholesterol than was thermogenic and electrical muscle stimulation following a standardized diet (Group EST) or electrical muscle stimulation and following a standardized diet, placebo controlled (Group ESP). An increased lipid level in the blood is termed hyperlipidemia. Cholesterol and triglycerides are the two most common lipids associated with coronary heart disease (CHD) risk. These fats do not circulate freely in the blood plasma, but rather are transported in combination with a carrier protein to form a lipoprotein. Serum cholesterol represents a composite of the total cholesterol contained in the different lipoproteins. The distribution of cholesterol among the various types of lipoproteins may be a more powerful predictor of heart disease than simply the total quantity of plasma lipids. The quantity of LDL and HDL, as well as the specific ratio of these plasma lipoproteins to each other and to total cholesterol, may provide a more meaningful signal than cholesterol per se in predicting the probability of contracting coronary heart disease. The ratio is improved with a low-calorie, low-saturated fat

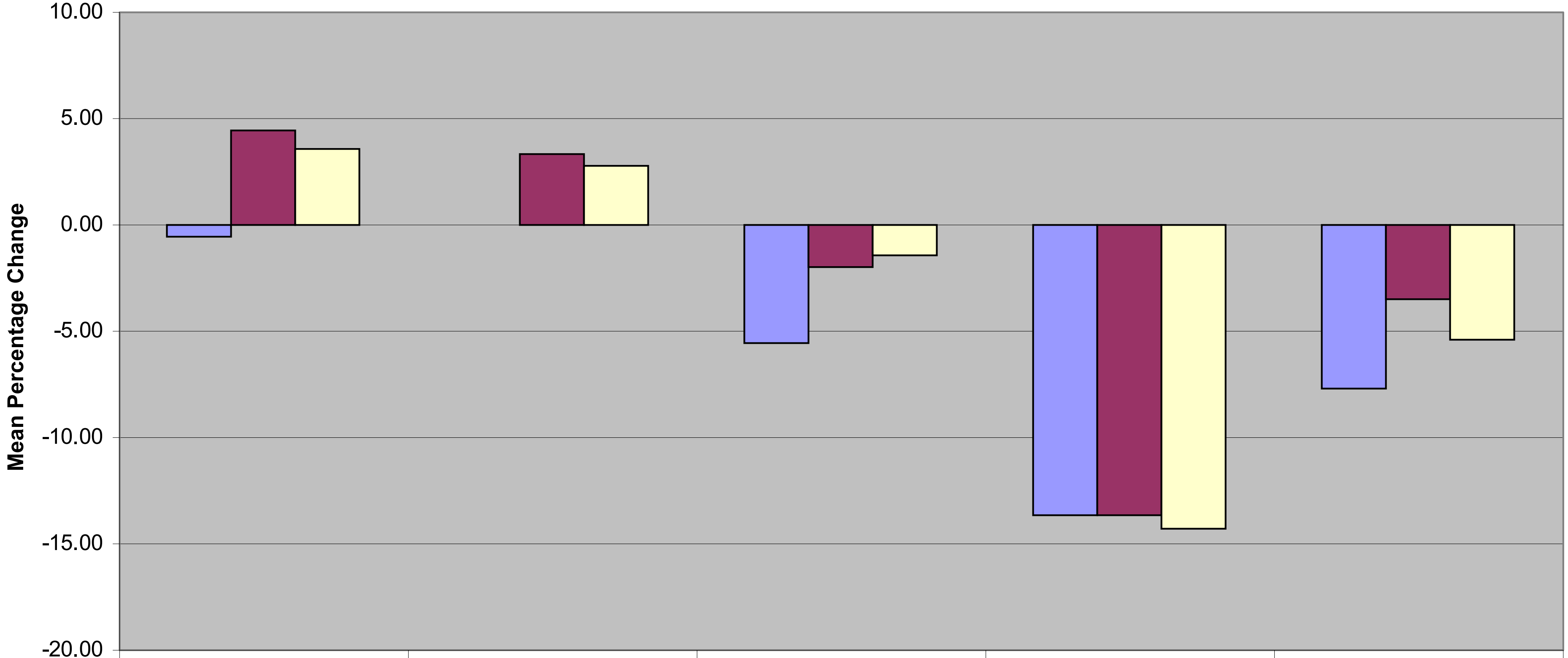
Table 4.6a: Heamatological Responses. Intra-Group Comparisons **(NS =p > 0,05; ∗ p ≤ 0,05)**

Groups		TS (n=20)						EST (n=20)						ESP (n=22)					
VARIABLES	UNITS	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p
Cholesterol	mmol/L	5.13	1.03	5.10	1.01	-0.03	NS	5.13	0.68	5.36	0.62	0.23	NS	4.99	0.90	5.17	1.21	0.18	NS
Cholesterol HDL	mmol/L	1.12	0.25	1.12	0.31	0.00	NS	1.21	0.27	1.25	0.29	0.04	NS	1.09	0.22	1.12	0.26	0.03	NS
Cholesterol LDL	mmol/L	3.60	0.98	1.01	0.44	-0.20	∗	3.47	0.60	3.40	0.71	-0.07	NS	3.49	0.85	3.44	0.99	-0.05	NS
Triglycerides	mmol/L	1.17	0.78	1.01	0.44	-0.13	NS	1.17	0.88	1.01	0.48	-0.16	NS	0.98	0.54	0.84	0.37	-0.14	∗
Glucose	mmol/L	4.95	0.42	4.57	0.43	-0.38	∗	4.90	0.66	4.73	0.61	-0.17	NS	4.97	0.83	4.70	0.73	-0.27	∗

Table 4.6b: Heamatological Responses. Inter-Group Comparisons **(NS =p > 0,05; ● p ≤ 0,05)**

Groups		TS	EST	ESP	Significance		
VARIABLES		%Δ	%Δ	%Δ	TS vs EST	TS vs ESP	EST vs ESP
Total Cholesterol	mmol/L	-0.58	4.48	3.61	NS	NS	NS
HDL-Cholesterol	mmol/L	0.00	3.31	2.75	NS	NS	NS
LDL-Cholesterol	mmol/L	-5.56	-2.02	-1.43	NS	NS	NS
Triglycerides	mmol/L	-13.68	-13.70	-14.29	NS	NS	NS
Glucose	mmol/L	-7.68	-3.47	-5.43	NS	NS	NS

Group TS---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).



	Total Cholesterol	HDL-Cholesterol	LDL-Cholesterol	Triglycerides	Glucose
TS	-0.58	0.00	-5.56	-13.68	-7.68
EST	4.48	3.31	-2.02	-13.68	-3.47
ESP	3.61	2.75	-1.43	-14.29	-5.43

Figure 4.6: Haematological Responses between Groups

diet. Regular and moderate levels of aerobic exercise may also increase the HDL level and favourably affect the LDL/HDL ratio (Manson et al., 1990).

4.6.2 LDL-Cholesterol

A lowering in LDL cholesterol level was observed within all three experimental groups. The greatest (5.56%) and only significant ($p \leq 0,05$) reduction in LDL cholesterol level was seen in those subjects on thermogenic stimulation following a standardized diet (Group TS) but this reduction did not differ significantly ($p > 0.05$) from those subjects on thermogenic and electrical muscle stimulation following a standardized diet (Group EST = 2.02%) or those subjects on electrical muscle stimulation following a standardized diet, placebo controlled (Group ESP = 1.43%).

Low density lipoproteins (LDL) contain the greatest fat and least protein components. The LDLs, which normally carry 60 to 80% of the total cholesterol, have the greatest affinity for the arterial wall. They help to carry cholesterol into the arterial tissue to become chemically modified and ultimately cause a proliferation of underlying smooth muscle cells and further changes that damage and narrow the artery in the process of coronary heart disease. The relation between high LDL cholesterol and death from coronary artery disease is not related to some threshold level but, instead, is continuous and graded so that any lowering of this blood lipid may offer cardio-protection. Numerous animal studies indicate that diets high in cholesterol and saturated fat raise LDL cholesterol in "susceptible" animals and eventually produce a degenerative process characterized by the formation of cholesterol rich plaque deposits on the inner lining of the medium and larger arteries. This process of arteriosclerosis leads to a narrowing and eventual closure of these vessels. In humans, a reduced saturated fat and cholesterol intake generally has a lowering effect on LDL cholesterol, although for most people the effect is modest.

4.6.3 HDL-Cholesterol

The greatest increase in HDL cholesterol was observed in group EST (3.31%). This increase in HDL cholesterol was closely followed by the increase found in group ESP (2.75%). There was no change in HDL cholesterol level found in group TS (0.00%). Although increases within groups were observed in group EST and group ESP none of these changes were statistically significant (p>0,05) nor differ significantly nor did they differ significantly (p>0,05) between groups.

HDL cholesterol may operate to protect against heart disease in two ways:

1. to carry cholesterol away from the arterial wall for degradation to bile in the liver and subsequently excreted by the intestines; and

2. to compete with the LDL cholesterol fragments for entrance into the cells of the arterial wall. Regular and moderate levels of aerobic exercise may also increase the HDL cholesterol level and favourably affect the LDL/HDL ratio (Manson et al., 1990). The above mentioned might be the reason for the increases in HDL cholesterol level found in those groups on electrical muscle stimulation (Group EST and Group ESP).

4.6.4 Triglycerides

Triglycerides, the most plentiful fat in the body, constitute the major storage form of fat (more than 95% of the body fat is in the form of triglycerides). Fatty acids released from triglycerides in the fat storage sites and delivered in the circulation to muscle tissue as free fatty acids (FFA) bound to blood albumin, as well as the triglycerides stored in the muscle cell itself, contribute considerably to the energy requirements of exercise.

Of all haematological responses tested the greatest reduction was found in triglyceride levels. The greatest reduction of all three experimental groups were found in group ESP (electrical muscle stimulation, following a standardized diet and placebo controlled) with a 14.29% reduction in triglyceride level. Both group EST (thermogenic stimulation following a standardized diet) and group TS (thermogenic and electrical muscle stimulation following a standardized diet) had the same reduction (13.68%) in triglyceride levels. None of these reductions in triglyceride levels within groups or between groups were statistically significant (p>0,05). All three experimental groups were on the same diet thus the reason for the same reduction in triglyceride levels. Only if exercise continues for an hour or more and carbohydrates become depleted then there is a gradual increase in the quantity of fat (triglycerides) utilized for energy (Plowman & Smith, 1997). Subjects in group EST and ESP were on electrical muscle stimulation for a duration of 45 minutes per session thus the influence of moderate exercise could not have had an influence on triglyceride levels.

4.6.5 Glucose

More than 200 monosaccharides have been found in nature. The most common of the monosaccharides are glucose, fructose and galactose. Glucose, also referred to as dextrose or blood sugar, is formed as a natural sugar in food or is produced in the body as a result of digestion of more complex carbohydrates or via the process of gluconeogenesis, whereby it is synthesized from the carbon skeletons of other compounds. After absorption by the small intestines, glucose can be used directly by the cell for energy, stored as glycogen in the muscles and liver, or converted to fats for energy storage. Fructose, or fruit sugar, is present in large amounts in natural form in fruits and honey and is the sweetest of the simple sugars. Although some fructose is absorbed directly into the blood from the digestive tract, it is all slowly converted to glucose in the liver. In the body, galactose is also converted to glucose for energy metabolism (Mc Ardle et al., 1996).

A significant ($p \leq 0,05$) decrease in glucose levels was observed within two of the experimental groups (TS and ESP). The largest decrease (7.68%) was seen in those subjects on thermogenic stimulation and following a standardized diet(Group TS) but this did not differ significantly ($p > 0,05$) from those on electrical muscle stimulation following a standardized diet, placebo controlled (Group ESP = 5.43%) or those on both thermogenic and electrical muscle stimulation following a standardized diet (Group EST = 3.47%). The decrease in glucose levels in all three experimental groups may be ascribed to the subjects being on the same diet for the duration of the study.

4.7 CARDIOVASCULAR RESPONSES

The results indicating cardiovascular response variables among the experimental groups are reflected in Table 4.7a & b and Figure 4.7.

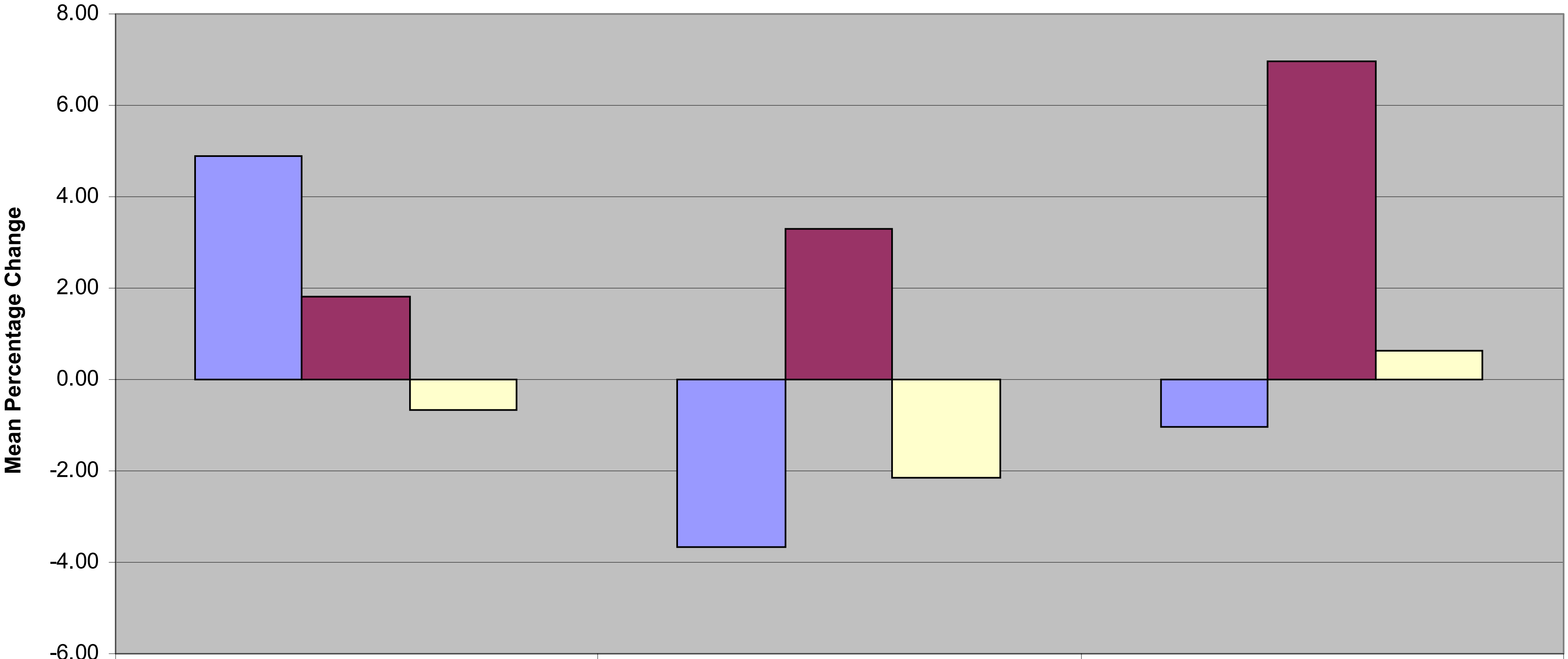
Table 4.7a: Cardiovascular Responses. Intra-Group Comparisons (NS =p > 0,05; ∗ p ≤ 0,05)

Groups		TS (n=20)						EST (n=20)						ESP (n=22)					
VARIABLES	UNITS	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p
Heart Rate	bpm	74.60	9.69	78.25	13.58	3.65	NS	68.80	10.83	70.05	10.47	1.25	NS	75.55	13.93	75.05	10.41	-0.50	NS
Systolic BP	mmHg	122.25	25.47	117.75	13.81	-4.50	NS	113.25	11.27	117.00	13.42	3.75	NS	117.05	12.97	114.55	11.54	-2.50	NS
Diastolic BP	mmHg	73.00	14.90	72.25	9.79	-0.75	NS	68.25	8.12	73.00	9.79	4.75	NS	70.91	9.71	71.36	9.41	0.45	NS

Table 4.7b: Cardiovascular Responses. Inter-Group Comparisons (NS =p > 0,05; ● p ≤ 0,05)

Groups		TS	EST	ESP	Significance		
VARIABLES		%Δ	%Δ	%Δ	TS vs EST	TS vs ESP	EST vs ESP
Heart Rate	bpm	4.89	1.82	-0.66	NS	NS	NS
Systolic BP	mmHg	-3.68	3.31	-2.14	NS	NS	NS
Diastolic BP	mmHg	-1.03	6.96	0.63	NS	NS	NS

Group TS ---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).



	Heart Rate	Systolic BP	Diastolic BP
TS	4.89	-3.68	-1.03
EST	1.82	3.31	6.96
ESP	-0.66	-2.14	0.63

Figure 4.7: Cardiovascular Responses between Groups

4.7.1 Heart rate

The only reduction in resting heart rate was noted in group ESP (0.66%). This reduction in heart rate in group ESP (electrical muscle stimulation following a standardized diet placebo controlled) did not differ significantly ($p>0,05$) from the increases found in group EST (thermogenic and electrical muscle stimulation following a standardized diet = 1.82%) and group TS (thermogenic stimulation following a standardized diet = 4.89%). Heart rate fluctuations in all three-study groups were ever so slight, and may be ascribed to anxiety levels of the subjects during the post-intervention testing.

4.7.2 Blood pressure

Systolic blood pressure

Both group TS (3.68%) and group ESP (2.14%) had reductions in systolic blood pressure levels. These reductions in systolic blood pressure levels did not differ significantly ($p>0,05$) from the increase found in group EST (3.31%).

Diastolic blood pressure

Only group TS showed a reduction (1.03%) in diastolic blood pressure. This reduction in diastolic blood pressure did not differ significantly ($p>0,05$) from the increases found in group ESP (0.73%) and group EST (6.96%). It is difficult to explain the slight increases found in diastolic blood pressure in groups ESP and EST. Group ESP was on a placebo and thus the influence of a thermogenic agent can be negated. The only group with a reduction in diastolic blood pressure was group TS (thermogenic stimulation following a standardized diet). The influence of a thermogenic agent (Group TS) on the lowering of diastolic blood pressure was thus positive. Groups ESP (electrical muscle stimulation, following a standardized diet and placebo controlled) and group EST (electrical muscle stimulation following a standardized diet) had increases in diastolic blood pressure. Both groups ESP and EST used electrical muscle stimulation in their intervention program. Although not statistically significant ($p>0,05$) the influence of electrical stimulation (Groups ESP and EST) on the lowering of diastolic blood pressure appears to be inversely related.

4.8 MUSCULOSKELETAL FUNCTION

The results indicating the response of musculoskeletal function variables among the experimental groups are reflected in Table 4.8a & b and Figure 4.8.

4.8.1 Flexibility

The sit-and-reach test was used to determine hip flexion (flexibility of the hamstrings and lower back). A positive percentage score is interpreted as an increase in hip flexion. There was a significant ($p \leq 0,05$) general increase in hip flexibility but no significant ($p > 0,05$) difference was observed between the modalities after eight weeks on the intervention programs. Although not statistically significant, group EST (21.22%) and group TS (18.04%) improved their hip flexibility more in relation to group ESP (12.11%).

People who are active tend to be more flexible than those who are not. The reason for this is that flexibility is motion dependent (Mentz, 2000). With little or no movement, muscles and other soft tissues tend to become shorter and tighter (Hockey, 1993). Subjects included in this study were deconditioned as evidenced by their low pre-intervention flexibility values. Obese people usually have difficulty in moving efficiently and their range of motion at certain joints is often restricted as excessive body fat (subcutaneous and visceral) usually limits flexibility. Fat deposits act as a wedge between moving parts of the body restricting movement (Hockey, 1993).

The increase in flexibility in all three experimental groups could be due to the reduction in body mass. An inverse relationship was evident when comparing the increase in flexibility with the decrease in subcutaneous fat in all three groups. The same tendency was found when flexibility was compared to visceral (intra-abdominal fat). The assumption can be made that the lower the fat % the higher the flexibility will be in obese females thus confirming the statement that excessive body fat limits flexibility and range of motion at certain joints. The results also indicate that light to moderate muscle action of gradually increasing intensity might be more appropriate for increasing flexibility than stretching itself.

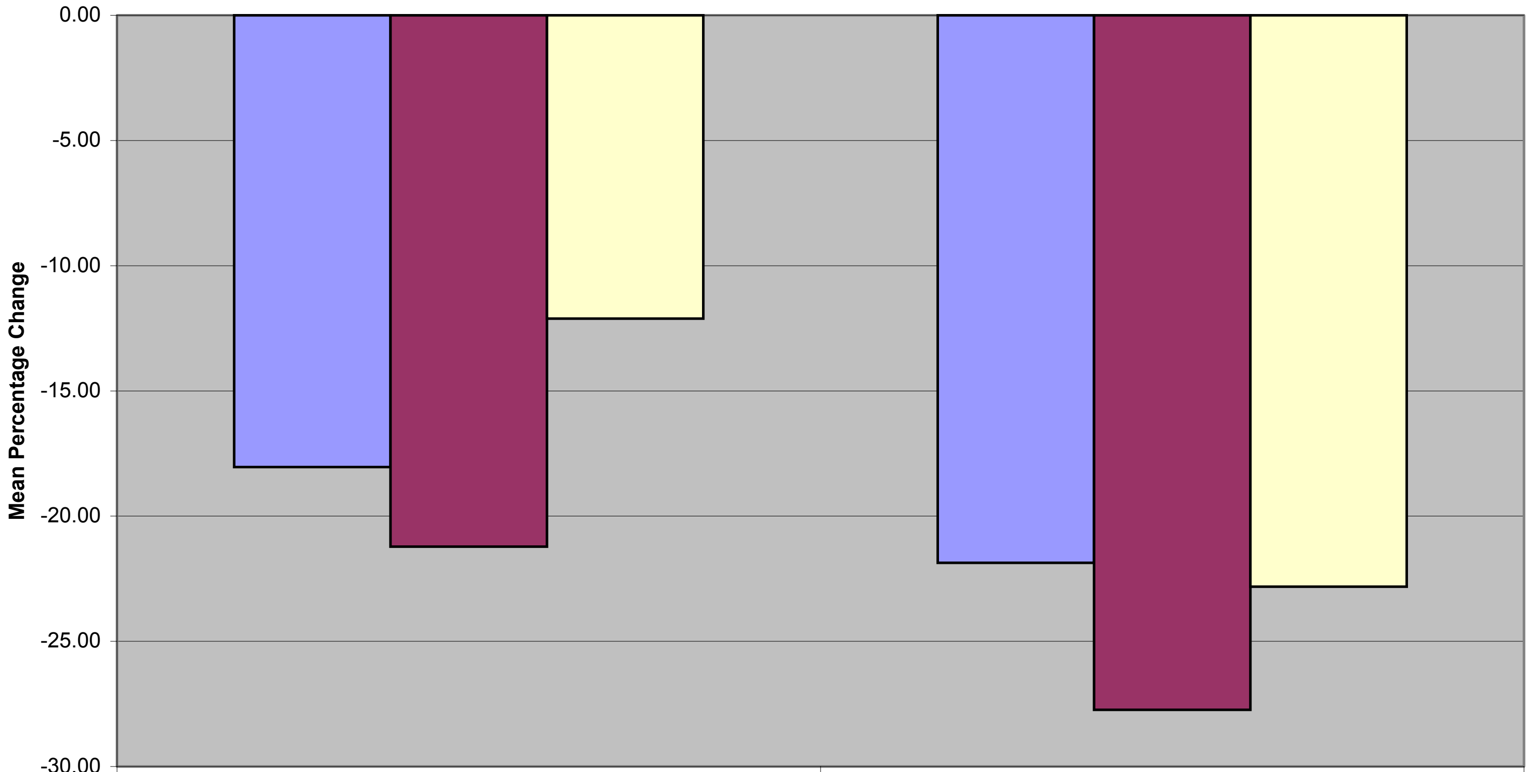
Table 4.8a: Musculoskeletal Function Responses. Intra-Group Comparisons (NS =p > 0.05; ∗ p ≤ 0.05)

Groups		TS (n=20)						EST (n=20)						ESP (n=22)					
VARIABLES	UNITS	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p	PRE Mean	Std. Dev.	POST Mean	Std. Dev.	Δ	p
Flexibility	cm	30.03	9.85	32.47	9.83	2.44	∗	32.25	6.71	35.10	6.17	2.85	∗	27.36	8.71	30.62	8.47	3.26	∗
Sit-Ups	no.	12.95	8.25	16.75	8.54	3.80	∗	16.45	9.08	20.75	9.93	4.30	∗	13.32	9.18	16.32	9.73	3.00	∗

Table 4.8b: Musculoskeletal Function Responses. Inter-Group Comparisons (NS =p > 0,05; ● p ≤ 0,05)

Groups		TS	EST	ESP	Significance		
VARIABLES		%Δ	%Δ	%Δ	TS vs EST	TS vs ESP	EST vs ESP
Flexibility	cm	18.04	21.22	12.11	NS	NS	NS
Sit-Ups	no.	21.87	27.74	22.82	NS	NS	NS

Group TS ---Thermogenic stimulation and following a standardized diet.
Group EST ---Electrical muscle stimulation and thermogenic stimulation following a standardized diet.
Group ESP ---Electrical muscle stimulation and following a standardized diet (Placebo controlled).



	Flexibility	Sit-Ups
TS	-18.04	-21.87
EST	-21.22	-27.74
ESP	-12.11	-22.82

Figure 4.8: Musculoskeletal Function Responses between Groups

4.8.2 Abdominal muscle endurance

Abdominal muscle endurance was evaluated with the maximum number of sit-ups performed in one-minute. Abdominal muscle endurance improved significantly ($p \leq 0,05$)in all three experimental groups. The greatest improvement was in group EST (27.74%) but this was not significantly ($p > 0,05$) better than the other two modalities, ESP (22.82%) and TS (21.87%).

Muscular endurance can be measured by how many isotonic repetitions of trunk flexion are performed in a designated period of time and should improve with exercise (Mentz, 2000). Thermogenic and electrical muscle stimulation following a standardized diet(Group EST) had the best effect on abdominal endurance, although not significantly more so than electrical muscle stimulation following a standardized diet, (placebo controlled, Group ESP) or thermogenic stimulation following a standardized diet (Group TS). Further significant strength toning and power gains could have been achieved through an increase in isotonic muscle involvement. There is no single best exercise to train abdominal muscles. A routine of low resistance and high repetitions favours abdominal muscle toning and endurance. Thus the impressive results found in both groups with electrical muscle stimulation (Group EST and ESP).

Fat deposits act as a wedge between moving parts of the body, restricting movements (Hockey, 1993). With a decrease found in both subcutaneous and visceral body fat in all three the experimental groups (EST, TS, ESP), the increase in the maximal number of sit-ups and thus abdominal muscle endurance, appears logical.