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Neuromuscular Electrical Stimulator as a Therapeutic Tool in Obesity

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Abstract: Obesity is one of the greatest public health challenges of the 21st century. In India, about 30-65% of urban adults are obese. The aim of this study was to investigate neuromuscular electrical stimulation (NMES) markers as a therapeutic tool in diagnosing the effectiveness of exercise intervention in obesity at different levels in obese Class I and Class II male subjects. This randomized controlled study was conducted in the physiotherapy outpatient department of Madha Hospital, Kovur, Chennai. The study duration was 12 weeks. The sample of 30 men was divided into the class I obese men group, 15 nos, and the class II obese men group, 15 numbers. The subjects of age between 18-50 years were included in the study. The Class III Obese men associated with co-morbidities were excluded in this study. The data of Randomized controlled study include anthropometric measurements like height, weight, BMI, Hip circumference, Waist circumference, Thigh circumference, Waist to Height ratio, Waist to Hip ratio, Waist to Thigh ratio, Sagittal abdominal diameter, Abdominal Skin fold thickness, Thigh skin fold thickness and NMES markers. Paired t-test analysis was done. SPSS 20 version was used to analyze the collected data. The result was presented as mean and standard deviation. There was a significant difference in mean values at P≤0.005 between different levels of study duration Class I and Class II obese men with neuromuscular electrical stimulator markers (NMES) as a Diagnostic tool. Thus, this study concludes that the NMES marker can be used as a therapeutic tool to analyze obesity.

Introduction

Obesity is one of the greatest public health problems in the 21st century. Obesity is defined as abnormal or excessive fat accumulation that leads to health risks. Obesity is assessed clinically using the body mass index (BMI), which is a person's weight (kilograms) divided by the square of height (meters). A person with BMI over 30 is considered obese (Xihua and Hong, 2021). The World Health Organization classified non-obese people as having a BMI between 25 and 30 (kg/m^2), obese person with BMI more than 30 (kg/m^2), class I obese with BMI 30-35 (kg/m2), class II obese, BMI 35-40 (kg/m2) and class III obese with a BMI over 40 (kg/m^2) (Clark et al., 2024). Obesity leads to an increased risk of developing chronic non-communicable diseases (NCD), including angina, hypertension, diabetes and stroke (Basak and Biswas, 2016; Madhu and sarkar, 2016; Posadzkiet al., 2020; Sarkar et al., 2021, 2022). Obesity is responsible for severe health costs and death in industrialized countries. Modifications in lifestyle, including exercise and routine, lead to weight loss and the prevention of weight gain.

Exercise is an important means of treating obesity. Exercise is a subset of physical activity that is planned, structured, repetitive, and purposeful in the sense of improving or maintaining physical fitness. Regular physical activity (PA) is considered an essential prevention component for most NCD (Oppert et al., 2021). Exercise programmes should be tailored to individual physical activity exercise responses. PA is

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defined as any bodily movement produced by skeletal muscles leading to an increase in energy expenditure. The health benefits of weight loss can be obtained with PA even without reaching optimal body weight, and they are associated with health benefits for improving risk factors (Raiman et al., 2023). Aerobic exercise can be considered a set of low-intensity, longer-period activities that make use of large muscle groups. They are defined as planned and structured body movements resulting in increased oxygen and calorie expenditure. Walking, jogging, stepping, swimming, and attending aerobic classes can be part of the weight-loss and weight-control program. Aerobic exercise is prescribed based on the percentage of maximum heart rate (%HR max), rate of perceived exertion (RPE) and Max oxygen consumption (% vo2 max). Aerobic training improves metabolism and decreases body weight, body circumference and fat mass. Resistance training increases lean body mass, strength and metabolic rate, leading to a decline in fat mass. Aerobic and resistance training effectively reduces total body mass and fat mass. Resistance training, diet and aerobic exercise favor and profoundly affect body composition in obese persons (Carla, 2017; Bai et al., 2022). Resistance training reduces both total body fat and visceral adipose tissue, causing weight loss (Amare et al., 2024).

Anthropometry methods estimate body fat, which includes general adiposity, such as central or abdominal obesity, visceral fat, and subcutaneous adipose tissue, by measuring the anthropometric markers. Anthropometry refers to measuring human body parameters such as the circumference of body parts and skin fold thickness (Piqueras et al., 2021; Khatun et al., 2016). Anthropometric markers include height, weight, BMI, waist-to-hip ratio and skin fold thickness, which are widely used because of their simplicity, ease of use, reduced exercise requirements, and less expensive equipment.

Neuromuscular electrical stimulator (NMES), also known as electrical muscle stimulator (EMS), is the elicitation of muscle contraction by an electrical impulse (Karamian et al., 2022). The electrical impulse produced by the stimulator is delivered to the motor point of the target muscle with an active electrode. In the physiotherapy department, transcutaneous or surface electrical muscle stimulation is used. As impedance or resistance increases due to electro-skin interface changes, the subcutaneous fatty layer intensity of current to elicit muscle contraction increases.

The motor point is the muscle location that exhibits brisk contraction at lowest level of stimulation. Transcutaneous electrodes use external leads that connect to a stimulator. Two electrodes placed in either a monopole or bipolar configuration are required to produce an electrical current flow. The active electrode is placed directly over the peripheral nerve or motor point. The inactive electrode is placed either on a fascia or tendinous insertion (monopolar technique) or near the active electrode (bipolar technique). NMES preferentially recruits superficial motor units, with deeper motor units progressively recruited as stimulation intensity. Thus, contraction strength increases. Applying NMES over the nerve trunk or motor point is better than applying it on the muscle belly. Delivering NMES over a nerve trunk can stimulate reflex pathways through the spinal cord, leading to evoked contraction (Nicola et al., 2011)

The NMES stimulus supplies electrons to depolarize the nerve. The number of electrons supplied per stimulus is equal to the current. The muscle repolarization to stimulus is called twitch. The most commonly used waveforms in electrotherapy are faradic current (SF), surged faradic current (SFC), Galvanic current (GC) and Interrupted galvanic current (IGC). In this study, surged faradic current (SFC) and interrupted galvanic current (IGC) were used (Nasma et al., 2022; Satardekar and Bhoir, 2017). Faradic currents have a pulse duration of 0.1 – 1 ms and a 50-100 Hz frequency. If peak current is applied to the subject, it increases and decreases rhythmically. The rate of increase and decrease of peak amplitude is slow, and the result of the current waveform is called a surged faradic current. Interrupted galvanic current pulses are square pulses with duration and frequency of impulse that can be adjusted. Duration of 100 ms with a frequency of 30 per minute is commonly used. The rise and fall of Intensity may be sudden (square) or gradual (Trapezoidal), triangular and saw tooth impulses. An optimal NMES utilize minimal stimulus frequency that produces a muscle contraction. The frequency range for NMES is 10 – 50 HZ. The objective of the study was to explore the role of NMES as a Therapeutic tool in class I and class II obese men.

Materials and Methods

This study was a Randomized controlled study conducted in department of physiotherapy, Madha hospital, Kovur, Chennai, for 6 months. Ethical approval for the study on human subjects was obtained from the research and ethical committee, SIMATS (Saveetha Institute of Medical and Technical Sciences). After explaining the benefit, outcome and scope of research, written informed consent from all the subjects was obtained before inclusion in the study. This study includes 30 subjects based on inclusion criteria and exclusion criteria. The subjects were divided into class I obese men (15nos) and class II obese men (15 numbers) using a stratified random sampling method.

Inclusion criteria

#Subjects with age group of 18 to 50 years of age.

#Male subjects were only included in the study.

#Subjects with BMI of obesity class I and class II.

Exclusion criteria

Women subjects are excluded

#Subjects with BMI of obesity class III.

Subjects with any associated co-morbidities such as cardiovascular diseases Musculo-skeletal disorders.

Subjects with chronic systemic disorder.

body heat, remove lactic acid, and mitigate the rise in potentially arrhythmogenic catecholamine and possibly reduce the risk of cardiac events during the recovery period (Westcott et al., 2009).

Resistance training (RT) involves a circuit-based training programme involving free weights, weight machines and resistance bands training frequency 2 to 3 days per week, 30 to 60 min per session with intensity at 60% of their estimated 1-Repetition maximum (1-RM). Resistance exercise includes exercise for the upper body (shoulder, arms), lower body (hip, thigh, legs) and, midsection (abdomen), back and chest with 8 to 10 muscle groups per session, 8 to 12 repetitions for each muscle groups, non-consecutive days a week (Strasser et al., 2011).

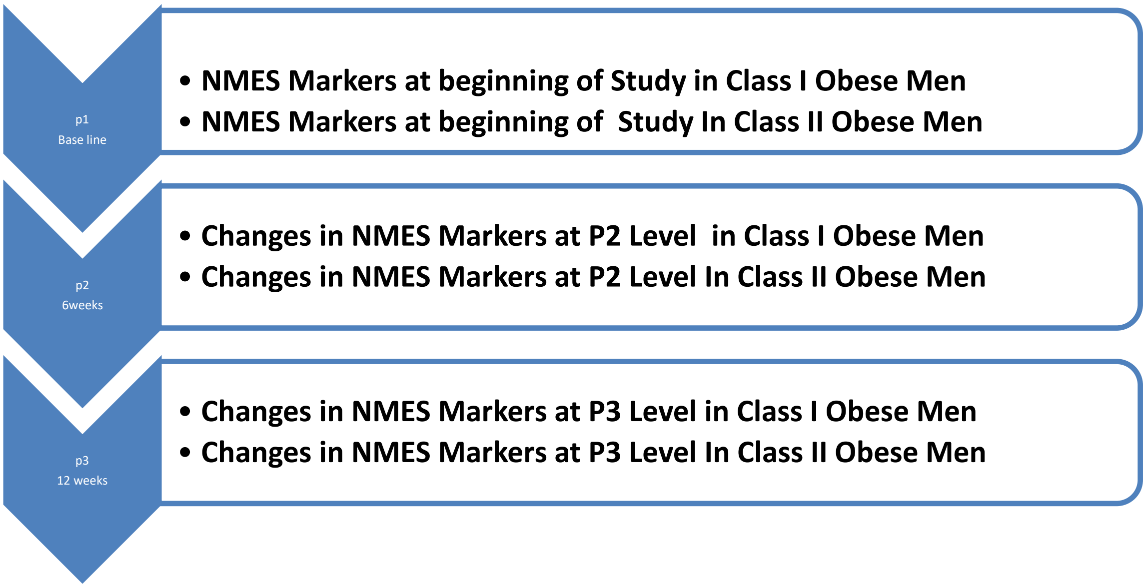

Figure 1. Randomized Control Trial Chart.

Exercise Intervention:

An exercise prescription has mode, intensity, duration, and frequency of exercise parameters. Components of a particular training session include the warm-up, conditioning phase, and cool-down. The 5- to 20-minute warm-up prepares muscles for more vigorous exercise and may reduce injuries. Stretching is incorporated in warm-up and is thought to reduce muscular injury. The conditioning phase, also referred as the Combined training programme (CT), consists of 12 weeks duration involving Aerobic training (AT) and Resistance Training (RT) (Linda et al., 2014).

Aerobic training (AT) involves Walking on a Treadmill, cycling, stepping exercises and Elliptical training with a frequency of 5 to 7 days per week, a duration of 250 to 300 minutes per week), with 45 to 60-minute sessions with moderate intensity exercises at 50% to 70% of maximal heart rate (MHR). This is followed by a 5 to 20-minute cool-down phase, which may attenuate post-exercise hypotension, allow better dissipation of

The combined training (CT) interventions consist of 12 weeks of AT and RT performed in the same exercise session and are more effective for obese persons in improving cardio-respiratory fitness and muscle strength (Murlasits et al., 2018). Flexibility exercises involve stretching for 15 seconds and are recommended at the frequency of 2 to 4 days per week, which improves joint, muscle and ligament movements incorporated in warm-up and cool-down sessions (Siddiqui et al., 2010)

Anthropometric Markers

Skin fold caliper measured skin fold thickness (SFT) of abdominal and Thigh muscles to estimate obesity. The right side was measured for convenience. The tester pinches the skin at the appropriate site to lift under-lying skin and adipose tissue, but not muscle. The caliper was then applied 1 cm below the right angle to the pinch, and a millimeter (mm) reading was taken. The mean of two measurements should be taken and if the two measures drift greatly a third measurement should be done and median values to be taken by the same examiner. Abdomen skin fold thickness (ASFT) subject in standing position, site-horizontal fold. 5 cm lateral to and at the level of the midpoint of the umbilicus (Johnson and Nelson,1982)

Thigh skin fold thickness (TSFT)- Subject in the seated position, site- front of thigh, halfway between inguinal grease and anterior patella along the long axis of femur. WHtR waist-to-height ratio is determined by the ratio between WC (cm) and height (cm) (Savva et al., 2013). The division between waist circumference and hip circumference estimates WHR waist-to-hip ratio.WTR waist to thigh ratio is found by dividing the waist circumference by the thigh circumference (Kahn HS et al., 1996).SAD sagittal abdominal diameter is measured in the supine position. It is the distance from the back to the upper abdomen (Sampaio et al., 2007).

Neuromuscular electrical stimulator (NMES) Markers

Neuro-muscular electrical stimulation (NMES) stimulates the nerve fibers by electrical impulses transmitted through electrodes placed on the skin over the motor point. Electrical stimulation parameters include frequency, pulse width/duration and intensity/amplitude. Subjects are positioned supine with hip and knee flexed to relax the abdominal muscle. Measurement is performed on the right-hand side of the body. Active electrode was placed above the motor point of abdominal muscle - external oblique (EO), Rectus abdominus (RO) and Thigh muscle – Vastus medialis (VM), Vastus lateralis (VL) (McCaughey et al., 2014). Muscle Motor Point location is identified by scanning the skin surface

Table 1. Descriptive Characteristic of the Study Samples over the course of the Study.

Markers	Class I Obese Men (n=15)			Class II Obese Men (n=15)		
	P1	P2	P3	P1	P2	P3
	X̄ ± SD	X̄ ± SD	X̄ ± SD	X̄ ± SD	X̄ ± SD	X̄ ± SD
Age	33.66±8.95	33.66±8.95	33.66±8.95	33.06±9.69	33.06±9.69	33.06±9.69
Height (cm)	161.33±7.26	161.33±7.26	161.33±7.26	159.53±5.06	159.53±5.06	159.53±5.06
Weight (kg)	89.73±6.35	86.53±6.42	83.60±6.57	91.2±4.75	88.46±4.85	86.06±4.77
BMI (kg/m2)	33.73±0.70	31.87±0.83	30.40±0.98	36.40±0.63	34.47±1.18	32.53±1.45
HC (cm)	98.20±2.45	97.27±2.63	96.53±2.53	102.13±2.92	101.40±2.89	100.73±2.84
WC (cm)	103.27±2.12	92.40±22.86	95.13±2.13	107.27±2.21	98.93±4.66	96.40±4.17
TC (cm)	42.47±1.99	40.53±1.92	38.73±1.53	42.60±2.38	40.47±2.20	38.53±1.84
WHtR	0.58±0.02	0.56±0.03	0.53±0.03	0.62±0.04	0.58±0.04	0.54±0.63
WHR	1.04±0.02	1.00±0.03	0.94±0.06	1.05±0.03	0.91±0.06	0.81±0.16
WTR	2.22±0.15	2.09±0.12	1.92±0.22	2.34±0.13	2.12±0.15	1.90±0.18
SAD	23.53±1.45	21.80±1.14	20.13±0.83	24.60±1.29	22.27±1.58	20.07±1.16
ASFT	30.73±1.94	27.20±2.24	24.20±2.54	32.20±1.78	29.93±1.58	26.47±1.84
TSFT	31.47±2.58	29.47±2.66	27.67±2.63	33.60±2.06	31.73±2.08	30.20±1.78
NMES-Abdominal-E0-SFC	32.27±5.50	30.47±5.35	28.53±5.20	32.27±5.50	28.47±8.82	28.53±5.20
NMES-Abdominal-E0 - IGC	38.00±4.44	35.67±4.11	33.47±3.98	38.20±4.64	35.67±4.11	33.47±3.98
NMES-Abdominal - RA - SFC	31.73±5.00	29.93±4.89	27.93±4.48	31.73±5.00	29.93±4.89	28.00±4.48
NMES-Abdominal - RA -IGC	36.60±4.77	34.47±4.35	33.00±4.50	36.60±4.77	34.67±4.45	33.00±4.50
NMES- Thigh - VM-SFC	37.47±2.90	34.73±0.81	32.40±0.81	37.46±2.89	34.73±3.17	30.46±8.12
NMES- Thigh-VM -IGC	41.47±0.53	39.20±0.50	36.93±0.53	39.13±9.94	39.20±1.93	36.93±2.05
NMES- Thigh - VL- SFC	35.87±3.31	33.53±3.04	31.00±2.87	35.86±3.13	33.53±3.04	31.00±2.87
NMES- Thigh - VL-IGC	40.27±4.33	37.80±4.47	35.87±4.17	40.20±4.33	38.00±4.45	35.93±4.16

*P1- Baseline P2- Week 6 P3- Week 12

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with a stimulation pen electrode (active or negative electrode) with a surface of approximately 1 $cm^2$and with a second electrode, usually called reference or dispersive or positive electrode larger than the active electrode that is placed over the antagonist muscle or opposite to the active electrode (Gobbo et al., 2014)

Results and Discussion

The collected data were tabulated and analyzed using both descriptive and inferential statistics. All parameters were evaluated using the Statistical Package for the Social Sciences (SPSS) version 20. An paired t-test was used to find a statistical difference between the groups of obese men of class I and II.

Body Mass Index (BMI)**,** Hip Circumference **(**HC), Waist Circumference (WC), Thigh Circumference (TC), Waist to Height ratio (WHtR), Waist-Hip ratio (WHR), Waist-Thigh ratio (WTR), Sagittal Abdominal Diameter (SAD), Abdominal Skin Fold Thickness (ASFT), Thigh Skin Fold Thickness (TSFT), Neuro Muscular Electrical Stimulation (NMES), External oblique (E0), Rectus Abdominal (RA), Surge Faradic Current (SFC), Interrupted Galvanic Current (IGC).

Table 1 compares demographic and anthropometric parameters between Class I and Class II obesity in men. BMI was significantly higher in p1>p2>p3 mean values of Class I and Class II obese men. The anthropometric markers WHtR, WHR, WTR, and SAD were significantly higher in p1>p2>p3 mean values of class I and Class II obese men.NMES markers of SFC and IGC on abdominal (External oblique and Rectus abdominus) and Lower limb (Vastus medialis and Vastus lateralis) were significantly higher in p1>p2>p3values of Class I and Class II obese men.

A comparison of the mean values of Anthropometric Markers in class I obese men shows a statistically significant difference in mean values between p1, p2 and p3 in table 2 at $p<0.05$ level.

Neuro Muscular Electrical Stimulation (NMES), External oblique (E0), Rectus Abdominal (RA), Surge Faradic Current (SFC), Interrupted Galvanic Current (IGC) $p<0.05$.

On comparison, the mean values of NMES Marker-surged faradic current (SFC) and Interrupted galvanic current (IGC) in class I obese men Abdominal – External oblique and Rectus abdominus and the Thigh muscle –

Table 2. Changes in NMES Markers Over the Course of Study in Class I Obese Men.

Markers	Between P1 and p2(n=15)			Between P1 and p3(n=15)			Between P2 and p3(n=15)		
	$\bar{X}$ ± SD	t - Value	p - Value	$\bar{X}$ ± SD	t - Value	p - Value	$\bar{X}$ ± SD	t - Value	p - Value
NMES-Abdominal - E0-SFC	1.80±0.86	8.08	0.000	3.73±1.03	14.00	0.000	1.93±0.59	12.61	0.000
NMES-Abdominal - E0 - IGC	2.33±0.81	11.06	0.000	4.53±0.91	19.17	0.000	2.20±0.41	20.57	0.000
NMES-Abdominal - RA- SFC	1.80±0.67	10.31	0.000	3.80±1.47	9.98	0.000	2.00±1.13	6.83	0.000
NMES-Abdominal - RA-IGC	2.13±1.12	7.34	0.000	3.60±1.18	11.78	0.000	1.46±1.30	4.36	0.001
NMES-Thigh - VM-SFC	2.73±0.79	13.25	0.000	5.06±1.38	14.14	0.000	2.33±0.81	11.06	0.000
NMES-Thigh - VM - IGC	2.26±1.48	5.90	0.000	4.53±1.59	10.99	0.000	2.26±0.59	14.78	0.000
NMES-Thigh - VL- SFC	2.33±0.48	18.52	0.000	4.86±0.91	20.58	0.000	2.53±0.74	13.20	0.000
NMES-Thigh - VL-IGC	2.46±0.91	10.43	0.000	4.40±0.82	20.57	0.000	1.93±0.70	10.64	0.000
P1- Baseline P2- Week 6 P3- Week 12									

Vastus medialis (VM) and Vastus lateralis (VL) it shows statistical significant difference in mean values between p1, p2 and p3 in table 2 at p<0.05 level.

Table 3. Changes in NMES Markers Over the Course of Study in Class II Obese Men.

Markers	Between P1 and p2(n=15)			Between P1 and p3(n=15)			Between P2 and p3(n=15)		
	X̄ ± SD	t - Value	p - Value	X̄ ± SD	t - Value	p - Value	X̄ ± SD	t - Value	p - Value
NMES-Abdominal - E0 - SFC	3.80±7.84	1.87	0.820	3.73±1.03	14.00	0.000	0.06±7.75	0.03	0.970
NMES-Abdominal - E0 - IGC	2.53±0.83	11.76	0.000	4.73±0.88	20.74	0.000	2.20±0.41	20.57	0.000
NMES-Abdominal - RA - SFC	1.80±0.67	10.31	0.000	3.73±1.48	9.72	0.000	1.93±1.16	6.43	0.000
NMES-Abdominal - RA -IGC	1.93±0.79	9.37	0.000	3.60±1.18	11.78	0.000	1.66±1.11	5.80	0.000
NMES-Thigh - VM-SFC	2.73±0.79	13.25	0.000	5.20±1.37	14.66	0.000	2.46±0.91	10.43	0.000
NMES-Thigh - VM - IGC	2.60±0.91	11.06	0.000	4.86±0.99	19.03	0.000	2.26±0.59	14.78	0.000
NMES-Thigh - VL-SFC	2.33±0.48	18.52	0.000	4.86±0.91	20.58	0.000	2.53±0.74	13.20	0.000
NMES-Thigh - VL-IGC	2.26±0.59	14.78	0.000	4.33±0.72	23.18	0.000	2.06±0.70	11.37	0.000
P1- Baseline P2- Week 6 P3- Week 12									

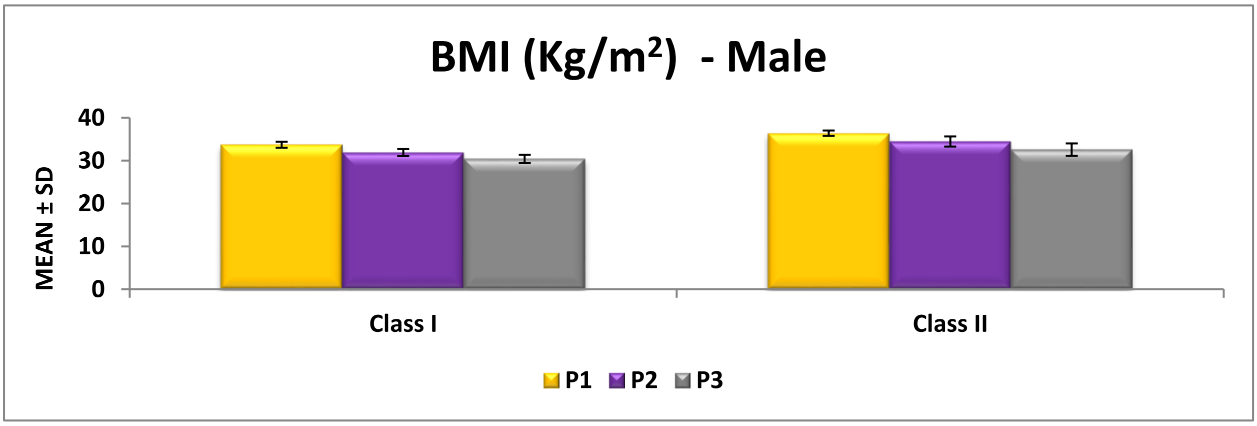

Figure 2. Body Mass Index (BMI) –Comparison between Class I and Class II obese men at P1, p2 and p3.

Neuro Muscular Electrical Stimulation (NMES), External oblique (E0), Rectus Abdominal (RA), Surge Faradic Current (SFC), Interrupted Galvanic Current (IGC) p<0.05.

On comparison, the mean values of NMES marker-surged faradic current (SFC) and Interrupted galvanic current (IGC) in class II men On Abdominal – External oblique and Rectus abdominus and Thigh muscle – Vastus medialis (VM) and Vastus lateralis (VL) it shows a statistical significant difference in mean values between p1, p2 and p3 in table 3 at p<0.05 level.

In this study, we evaluated the application of NMES as a therapeutic tool in obesity in Class I men and Class II men. Obesity occurs due to a sedentary lifestyle and caloric over consumption. Sedentary lifestyle is one of the predisposing factors for overweight and obesity, which leads to several diseases like cardiovascular

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diseases such as hypertension, diabetes and angina. Effective intervention programmes include dietary modification and energy expenditure. Exercise prescription to treat obesity prevents additional weight gain, reduction of body weight and long-term maintenance of reduced body weight (Wu et al., 2009). Reviewed effects of combined diet and exercise intervention.

The combined diet and exercise show long-term weight loss. Our study has shown aerobic exercise is beneficial in reducing body weight and body mass index (BMI). Thus to reduce body fat, exercise intensity should be 50 to 60% of MHR.

In paired T-test analysis of BMI markers in class I and class II obese men, it is observed that mean value and SD at P1 (Base-line), p2 (6^{th} week) and p3 (12^{th} week) are statistically significant between p1 and p2, p1 and p3, p2 and p3 at $P<0.05$ level from figure 2.

Anthropometric Markers-BMI- between p1 & p2 (1.86 ± 0.91), p1 & p3 (3.33 ± 1.34), p2 & p3 (1.46 ± 0.91) Class I obese men BMI-between p1 & p2 (1.93 ± 1.03), p1 & p3 (3.86±1.30), p2 & p3 (1.93±0.70) Class II obese men (Donnelly et al., 2013) also investigated that aerobic exercise alone results in clinically significant body weight loss in men.

It was seen that body mass index decreased in the study of (Monteiro et al., 2015), and this study presented. Therefore, parallelism has been seen between the BMI

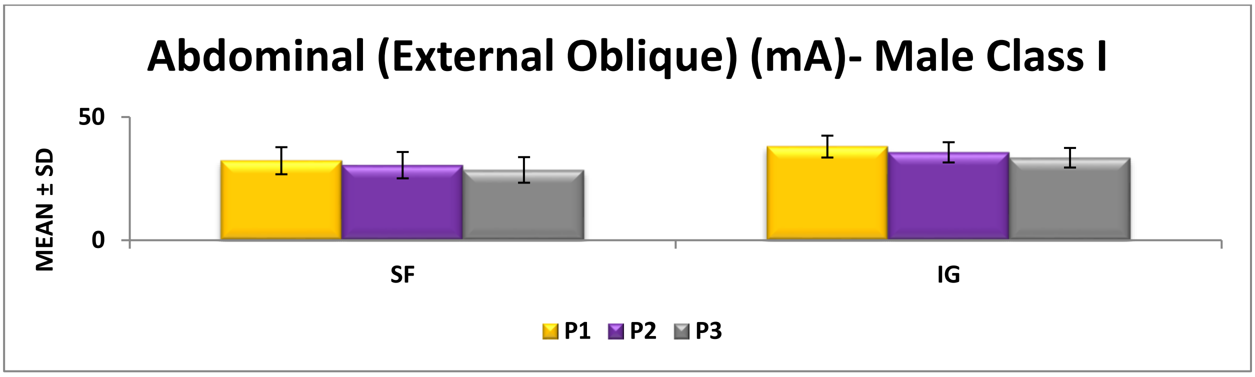

Figure 3. Abdominal (External Oblique) NMES Marker –Comparison between SF & IG current for Class I obese men at P1, p2 and p3.

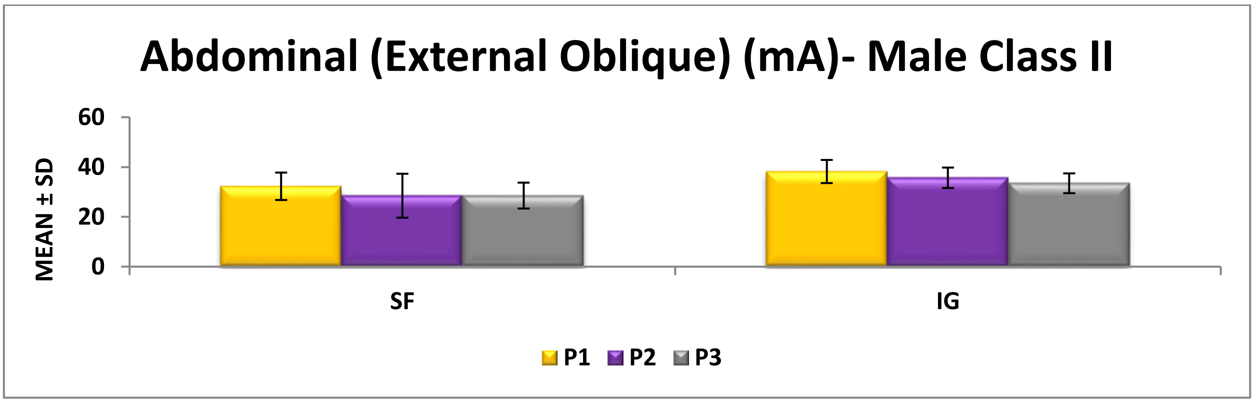

Figure 4. Abdominal (External Oblique) NMES Marker –Comparison between SF & IG current for Class II obese men at P1, p2 and p3.

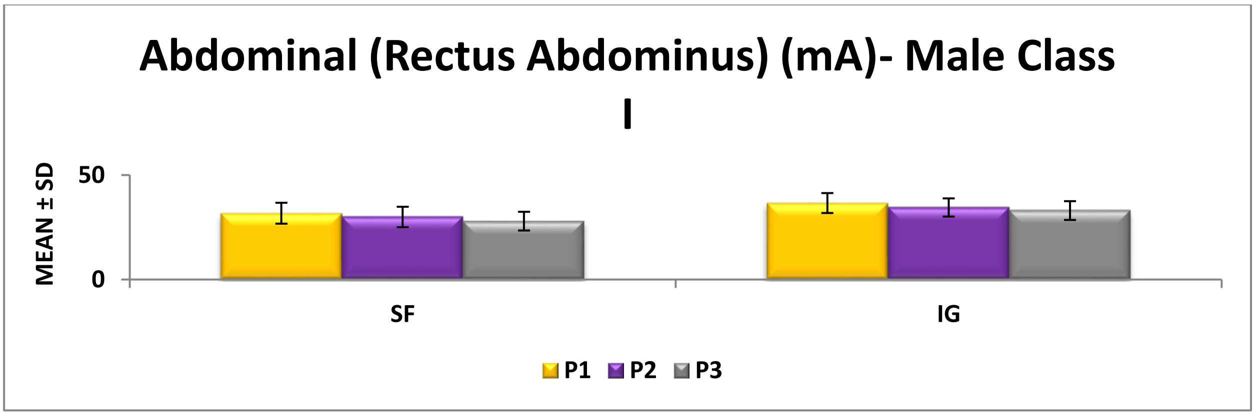

Figure 5. Abdominal (Rectus Abdominus) NMES Marker –Comparison between SF & IG current for Class I obese men at P1, p2 and p3.

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findings of the studies as mentioned above and this study. The most effective exercise form in exercise therapy is "Aerobics exercise" which provides the rhythmic training of big muscle groups for specific periods of time. The more the span and the frequency of the exercise, the better the effects received (Aksoydan and Cakir, 2011), and a meaningful difference was found in the relationship between physical activity, body mass index (BMI), and body composition.

Nazni et al. (2006) studies showed that 30 minutes of treadmill and walking exercise reduce Body Mass Index (BMI) and reduce the risk of obesity and good body composition.

It was asserted that aerobics exercises decrease body fat and weight, and subcutaneous fat aerobics exercises were stated to be effective in this respect. All the variables in the study have also been found in this study and aerobics exercise is seen to be effective in all measurements, so it supports the findings of this study (Donnelly et al., 2003).

Gobbo et al. (2011) clearly evidenced that NMES delivered through individual identified Motor point is important in eliciting the muscular contraction and minimizing the current intensity and discomfort.

When NMES is applied over the motor unit of the muscle belly, it recruits superficial motor units with progressively deeper motor units as stimulation in intensity gradually increases, leading to flickering to evoked muscular contraction (Mesin et al., 2010; Okuma et al., 2013).

Gandevia(2001) stated NMES can be used as a valid research tool to evaluate the contractile function of intact muscle in a standardized way e.g., level of voluntary activation using electrotherapy technique.

In paired T-test analysis of NMES markers in Class I and Class II obese men of Abdominal - External Oblique (EO), Comparison between SF & IG current at P1 (Base-line), p2 (6^{th} week) and p3 (12^{th} week) it is observed that the mean value and SD are statistically significant between p1 and p2, p1 and p3, p2 and p3 at P<0.05 level from figure 3 and 4.

NMES- Abdominal - EO-SFC between p1 & p2 (1.80±0.86), p1 &p3 (3.73±1.03), p2 & p3 (1.93±0.59) Class I obese men EO-IGC between p1 & p2 (2.33±0.81), p1 & p3 (4.53±0.91), p2 & p3 (2.20±0.41) Class I obese men.

NMES- Abdominal - EO-SFC between p1 & p2

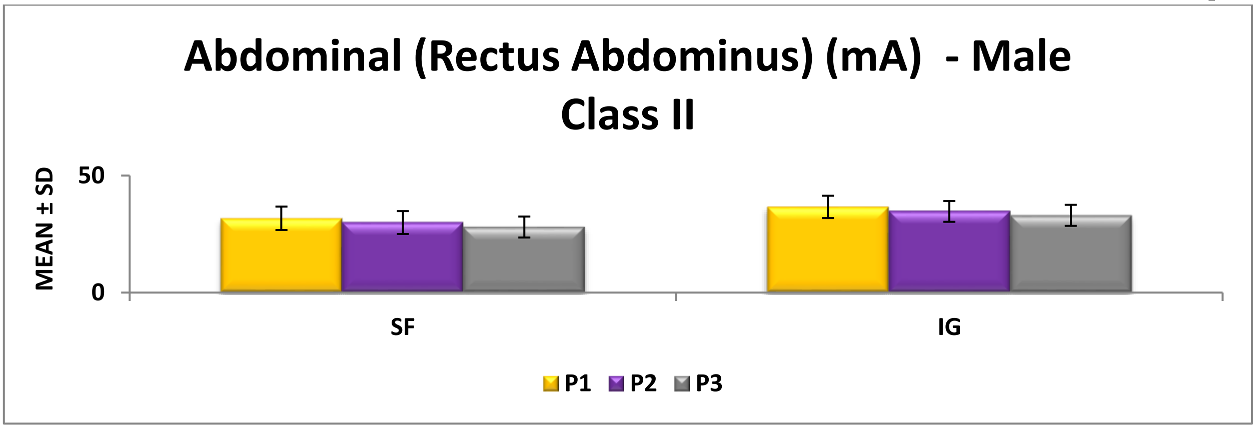

Figure 6. Abdominal (Rectus Abdominus) NMES Marker –Comparison between SF & IG current for Class II obese men at P1, p2 and p3.

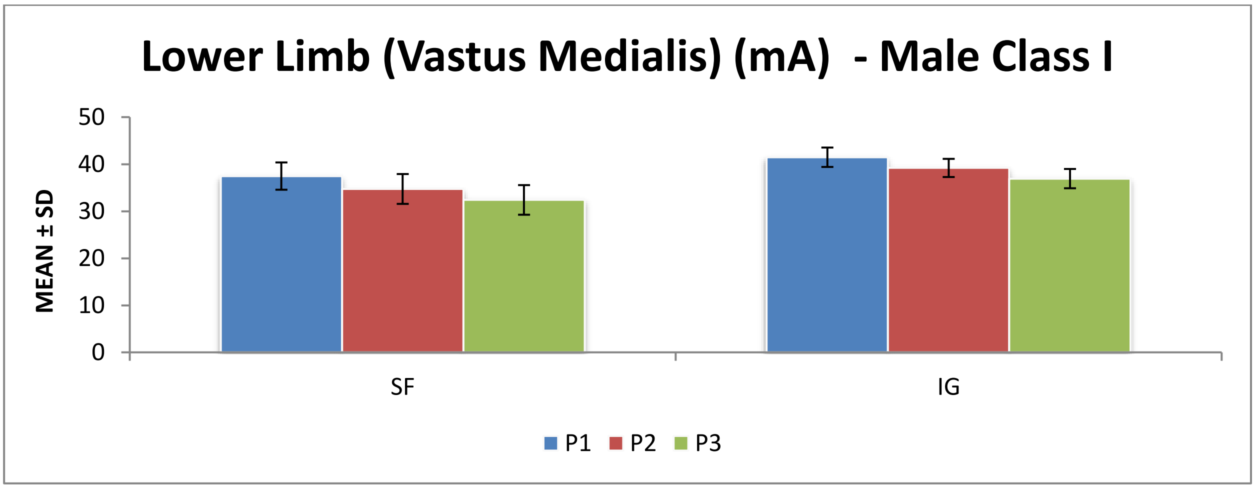

Figure 7. Lower Limb (Vastus Medialis) NMES Marker –Comparison between SF & IG current for Class I obese men at P1, p2 and p3.

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(3.80±7.84), p1 & p3 (3.73±1.03), p2 & p3 (0.06±7.75) Class II obese men EO-IGC between p1 & p2 (2.53±0.83), p1 & p3 (4.73±0.88), p2 & p3 (2.20±0.41) Class II obese men.

In paired T-test analysis of NMES markers in Class I and Class II obese men of Abdominal - External Oblique (EO), Comparison between SF & IG current at P1 (Base-line), p2 (6th week) and p3 (12th week) it is observed that the mean value and SD are statistically significant between p1 and p2, p1 and p3, p2 and p3 at $P<0.05$ level from figure 3 and 4.

NMES- Abdominal -EO-SFC between p1 & p2 (1.80±0.86), p1 &p3 (3.73±1.03), p2 & p3 (1.93±0.59) Class I obese men EO-IGC between p1 & p2 (2.33±0.81), p1 & p3 (4.53±0.91), p2 & p3 (2.20±0.41) Class I obese men.

NMES- Abdominal -EO-SFC between p1 & p2 (3.80±7.84), p1 & p3 (3.73±1.03), p2 & p3 (0.06±7.75) Class II obese men EO-IGC between p1 & p2 (2.53±0.83), p1 & p3 (4.73±0.88), p2 & p3 (2.20±0.41) Class II obese men.

In paired T-test analysis of NMES markers in Class I and Class II obese men of Abdominal – Rectus abdominus (RA), Comparison between SF & IG current at P1 (Base line), p2 (6th week) and p3(12th week) it is observed that the mean value and SD are statistically significant between p1 and p2, p1 and p3, p2 and p3 at $P<0.05$ level from figure 5 and 6.

NMES- Abdominal-RA-SFC between p1&p2 (1.80±0.67), p1 & p3 (3.80±1.47), p2 & p3 (2.00±1.13)

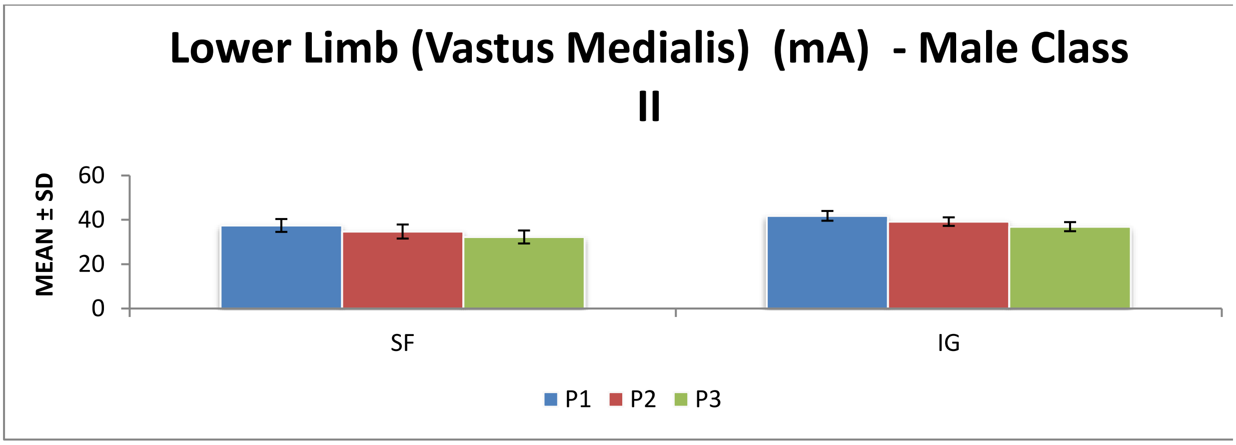

Figure 8. Lower Limb (Vastus Medialis) NMES Marker –Comparison between SF & IG current for Class II obese men at P1, p2 and p3

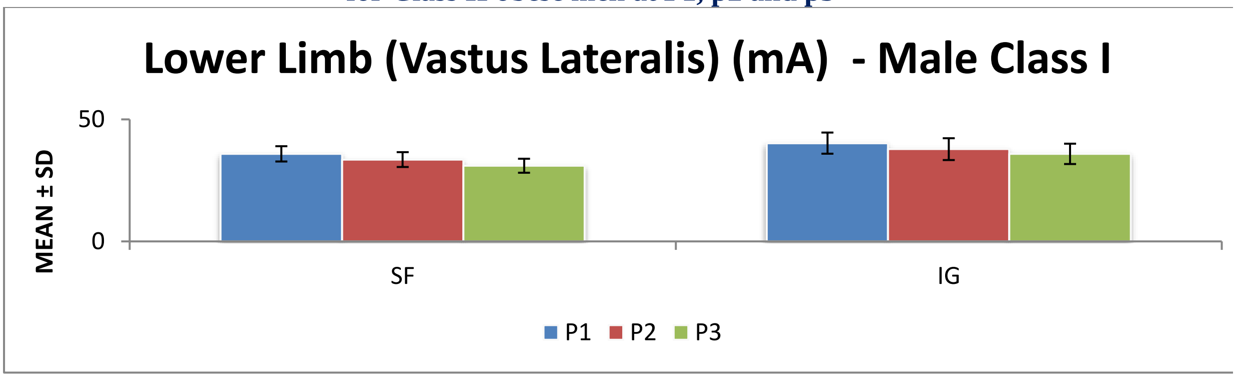

Figure 9. Lower Limb (VastusLateralis) NMES Marker –Comparison between SF & IG current for Class I obese men at P1, p2 and p3.

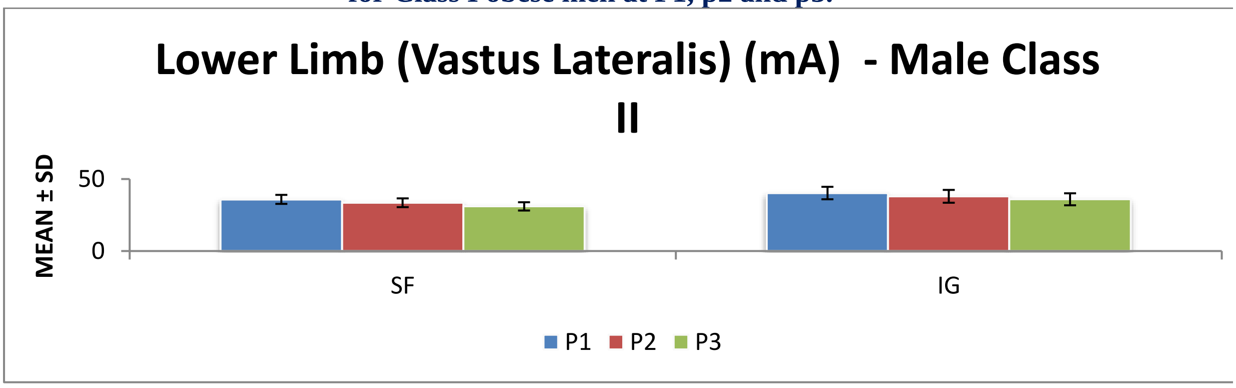

Figure 10. Lower Limb (Vastus Lateralis) NMES Marker –Comparison between SF & IG current for Class II obese men at P1, p2 and p3.

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Class I obese men RA-IGC between p1&p2 (2.13±1.12), p1 & p3 (3.60±1.18), p2 & p3 (1.46±1.30) Class I obese men.

NMES- Abdominal - RA-SFC between p1&p2 (1.80±0.67),p1&p3 (3.73±1.48), p2& p3 (1.93±1.16) Class II obese men RA-IGC between p1 & p2 (1.93±0.79), p1 & p3 (3.60±1.18), p2 & p3 (1.66±1.11) Class II obese men.

In paired 't' test analysis of NMES markers in Class I and Class II obese men of Lower Limb – Vastus Medialis (VM), Comparison between SF & IG current at P1 (Base-line), p2 (6^{th} week) and p3(12^{th} week) it is observed that the mean value and SD are statistically significant between p1 and p2, p1 and p3, p2 and p3 at $P<0.05$ level from figure 7 and 8.

NMES- Lower Limb-VM-SFC between p1 & p2 (2.73±0.79),p1 & p3 (5.06±1.38), p2 & p3 (2.33±0.81) Class I obese men VM-IGC between p1 & p2 (2.26±1.48), p1 & p3 (4.53±1.59), p2 & p3 (2.26±0.59) Class I obese men.

NMES - Lower Limb-VM-SFC between p1 & p2 (2.73±0.79), p1 & p3 (5.20±1.37), p2 & p3 (2.46±0.91) Class II obese men VM-IGC between p1 & p2 (2.60±0.91), p1 & p3 (4.86±0.99), p2 & p3 (2.26±0.59) Class II obese men.

In paired t-test analysis of NMES markers in Class I and Class II obese men of Lower Limb –Vastus Lateralis (VL), Comparison between SF & IG current at P1 (Base-line), p2 (6^{th} week) and p3(12^{th} week) it is observed that the mean value and SD are statistically significant between p1 and p2, p1 and p3, p2 and p3 at $P<0.05$ level from figure 9 and 10.

NMES - Lower Limb-VL-SFC between p1 & p2 (2.33±0.48), p1 & p3 (4.86±0.91), p2 & p3 (2.53±0.74) Class I obese men. VL-IGC between p1 & p2 (2.46±0.91), p1 & p3 (4.40±0.82), p2 & p3 (1.93±0.70) Class I obese men.

NMES - Lower Limb-VL-SFC between p1 & p2 (2.33±0.48), p1 & p3 (4.86±0.91), p2 & p3 (2.53±0.74) Class II obese men.

VL-IGC between p1 & p2 (2.26±0.59), p1 & p3 (4.33±0.72), p2 & p3 (2.06±0.70) Class II obese men.

Grimnes and Martinsen (2000) have done extensive work in skin electrical prosperities, but no studies investigate the skin response to a standardized voltage pulse. The important difference to be noticed between previous studies and our studies is we investigated the surge faradic current (SFC) and interrupted galvanic current (IGC) Neuro-muscular Electrical Stimulator (NMES) marker as a therapeutic tool in the management of Class I and Class II obese men.

Previous research studies examined the use of NMES (neuromuscular electrical stimulation) for therapeutic purposes, such as treating obesity in rehabilitation. NMES is a non-invasive, cost-effective, and readily available tool commonly used in electrotherapy departments. However, no studies have utilized NMES as a therapeutic tool in assessing the effectiveness of exercise intervention in evaluating obesity.

It has been found that the model we propose may be applied towards a better understanding of the changes occurring in the skin's electrical properties in various circumstances, such as changes in skin electrical properties during the NMES session.

Conclusion

Physical inactivity, a condition seen in overweight and obese individuals, is associated with an increase risk of developing NCD (Emerenziani et al., 2013). Since obesity results from chronic energy imbalance where intake exceeds expenditure, Physical activity (PA) plays a vital role in body weight management. Our studies suggest that Combined training (CT) involving Aerobic training (AT) and Resistance training (RT) interventions yield a loss in body weight and anthropometric markers. Moderate physical activity prevents weight regain after weight loss. Increasing physical activity in daily life can be effective in managing weight as much as regular exercise. NMES marker can be used to analyze obesity as a therapeutic tool by analyzing the intensity of electrical stimulus required to elicit muscular contraction after exercise intervention

Conflict of Interest

The authors declare no conflict of interest.

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