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Research Article

Efficacy of Two Distinct Photo biomodulation Therapy Intensities on Muscle Strength and Fatigue in Type 2 Diabetes Mellitus

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ABSTRACT

Background: Diabetes mellitus refers to a collection of metabolic illnesses characterized by deficiencies in insulin secretion, insulin action, or both, as well as disruptions in carbohydrate, lipid, and protein metabolism, resulting in decreased muscular performance. Photo biomodulation therapy is also called as Low-level laser therapy. It has thought to improve muscle strength and minimize muscle fatigue in type 2 diabetes patients. The aim of this research is to determine the effectiveness of two different intensities of low-level laser treatment (LLLT) on muscle strength and tiredness in patients with type 2 diabetes mellitus.

Methods: A quasi-experimental study was conducted on 30 participants with type 2 diabetes mellitus, who were divided into three groups. Pre-interventional measures included the MRC grading scale for strength evaluation and the FSS for tiredness. Experimental group A (n=10) received 5J/cm2 LLLT, experimental group B (n=10) received 7J/cm2 LLLT, and group C (n=10) underwent moderate intensity resistance training, 12 repetitions, 3 sets for ankle plantar flexors and dorsi flexors once a day, four days a week, for four weeks. Post-interventional outcomes were assessed with the MRC grading scale for strength and FSS for fatigue.

Results: The statistical analysis of the data reveals that experimental group B subjects have made significant improvements in their muscle strength and fatigue levels. The p-values for MRC and FSS in experimental group B participants are 0.0002 and 0.0001, respectively.

Conclusions: Low-level laser therapy is beneficial in improving muscle strength and reducing muscle fatigue in people with type 2 diabetes. The statistical analysis revealed that group A (LLLT at 7 Joules of intensity) improved muscular performance more than group B or the control group.

Key words: Type 2 Diabetes mellitus, Muscle strength, Fatigue, Photobiomodulation therapy, Low Level Laser therapy, different intensities, MRC, FSS.

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INTRODUCTION:-

Diabetes refers to a collection of metabolic illnesses distinguished by the presence of hyperglycemia, with a varied etiology that includes problems in insulin production, insulin action, or both, as well as disruptions in carbohydrate, lipid, and protein metabolism.[1] Type 2 diabetes mellitus (T2DM) is characterized by dysregulation of carbohydrate, lipid, and protein metabolism, which comes from decreased insulin production, insulin resistance, or both. Commonest type (representing over 90% of all instances).[2] According to the International Diabetes Federation, 382 million persons aged 20 to 70 had type 2 diabetes in 2013, with 80% of those affected residing in low- and middle-income countries. This figure is predicted to increase to 592 million by 2035.10 The prevalence of diabetes is rising worldwide. India has seen the greatest increase over the previous few years. The prevalence of type 2 diabetes mellitus is 2.4% in rural areas and 11.6% in cities.[3]

Pathophysiological alterations include β-cell malfunction, insulin resistance, and chronic inflammation, which can impair blood glucose management and cause vascular problems.3 B-cell failure can be caused by a variety of factors, including ageing, genetic abnormalities, resistance to Incretin hormones (GLP1 and GIP), lipotoxicity, glucotoxicity, insulin resistance, hypersecretion of IAPP, reactive oxygen stress, and activation of inflammatory pathways.[3] Insulin resistance leads to a higher prevalence of α-cells than β-cells, probably because to selective β-cell death.[4] Insulin resistance, hyperglycemia, muscle fat infiltration, peripheral neuropathies, and oxidative stress are considered to be the main molecular factors causing deficiencies in muscle strength in patients with diabetes.[5] Muscle strength naturally decreases with age; however, patients with type 2 diabetes show a larger drop with age.[5] As lack of physical exercise is one of the fundamental processes in the development of DM2, inactivity and disuse most likely contribute to the comparatively weak muscle strength.[6]
Loss of muscle mass and strength reduces the surface area available for glucose transport, exacerbating insulin resistance. Inflammation, which is a major cause of insulin resistance, is linked to decreased muscle strength. Higher levels of tumor necrosis factor-alpha (TNF-α) were linked to decreased muscle strength and increasing levels of inflammatory markers, including CRP and IL-6, which can predict the development of type 2 diabetes[7]**.**

Diabetes and weariness appear to have a bidirectional relationship, feeding and exacerbating each other. This link is strengthened by biological, psychological, and lifestyle variables.[8] In diabetics, a deficiency of insulin (compared to the body's requirements) may shift the energy source from glucose to fat. When glycogen stores are depleted, the ADP phosphorylation rate decreases, and ATP resynthesis slows. This process could explain the prevalence of weariness in diabetes.[8]

The most prevalent cause of muscle weariness is an increase in hydrogen ions, which inhibits contractile performance. Alternative hypotheses have included the effects of ionic changes on muscle action potential, such as the presence of inorganic phosphate (Pi) and magnesium ions, the absence of Ca2+ or its release via various mechanisms, and the effects of reactive oxygen species.[9]

Resistance exercise lowers glycosylated hemoglobin (HbA1c), total fat mass, and improves insulin resistance. Resistance band training can help control strength based on personal physical condition and offer the appropriate, tailored load by progressively increasing band resistance as muscle strength improves. Furthermore, it has been shown to be a beneficial exercise modality for increasing muscle and physical strength while minimizing stress on each joint or muscle.[10] Whole-body vibration (WBV) training is a relatively new type of exercise that has been found to improve glycemic management, lipid-related cardiovascular risk factors, and muscular performance in type 2 diabetes mellitus patients.[11] Aerobic and resistance exercise significantly improves body composition, glycemic management, lipid profile, leg muscle strength, and walking capacity in older patients with a long history of type 2 diabetes.[12]Laser therapy is part of a therapeutic system known as photobiomodulation, which is a soft tissue treatment procedure that uses light wave energy. This approach employs a wide range of wavelengths, from red (630-660nm) to infrared (808-950nm), depending on the desired effect. The infrared spectrum is more absorbable and has more therapeutic benefits. Laser devices can be classified in a variety of ways, including the spectrum of emitted radiation, the active medium (semiconductor, gas, liquid, and solid), the nature of the operation (pulsed or continuous), and the range of power and energy emitted by the device.[13]

Two primary PBT properties appear to have the greatest impact on cell biology. The wavelength ranging from 600 to 1070 nm have the greatest impact on cell proliferation. This behavior is most likely caused by light absorption or interference outside of this wavelength range. Light with shorter wavelengths is strongly absorbed by haemoglobin, whereas longer wavelengths are absorbed by water. The second significant consideration is energy density. In general, lower energy density (0.05 J/cm2-10 J/cm2) stimulates cell proliferation, while higher energy density (over 50 J/cm2) increases apoptotic processes. The mutual transition between the two phenomena is continual. This biphasic reaction is referred to as the "Arndt-Schulz law".[13]

Photo biomodulation therapy or PBT, has emerged as a novel treatment for injury prevention and muscular pain management. The postulated mechanism of PBT activity is the stimulation of the mitochondrial system and the influence on cytochrome C oxidase, which increases muscle strength by accelerating ATP generation, resulting in fatigue delay and muscle protection against injury. PBT reduces the development of fatigue-associated indicators such as lactate dehydrogenase (LDH), C-reactive protein (CRP), and creatine kinase (CK), and by boosting the oxidase system, reduces oxidative stress and elevates muscle buffering capacity.[14] Infrared wavelengths are mostly absorbed in mitochondria, where they directly intervene in the cellular respiration process, allowing for the immediate entry of oxygen, the restoration of the respiratory chain, and, as a result, the acceleration of intracellular ATP generation. Given that muscle activity needs a high energy expenditure, it is thought that resources that maximize ATP production may also improve muscle strength and function.[14] The study's aim is to determine the effects of two distinct intensities of photo biomodulation therapy on muscle strength and tiredness in type 2 diabetics. To investigate the hypothesis regarding the effects of two distinct intensities of low-level laser therapy on muscle strength and tiredness in type 2 diabetes mellitus participants.

METHODOLOGY:-

The study aimed to determine the impact of photobiomodulation therapy on muscle strength and tiredness in people with type 2 diabetes mellitus.

Study design: Quasi experimental study

Study settings: The study was carried out at physiotherapy OPD in the Apollo District Headquarters Hospital, Murukambarttu, Chittoor-517001, Andhra Pradesh, India.

Study subjects: A total of 30 patients, both men and women, over the age of 50 with type 2 diabetes mellitus for 5-10 years are selected from the physiotherapy department and willing to participate in the study at the Apollo district headquarters hospital in Chittoor.

Inclusion criteria: HbA1C values > 6.5, Diabetes duration of 5-10 years after diagnosis, Age limit > 50 year, Muscle power ≤ 4, Both genders are included, Participants signed consent and agreed to participate.

Exclusion criteria: Patients who are not willing and cooperative, Patients with type 1 diabetes, Diabetic neuropathy patients, Patients with unstable vital signs Patients with cardiac abnormalities. Malignant tumors Pregnancy, alcoholics, and peripheral vascular disease.

Sample size: 30
Study sample: Consecutive sampling.

Treatment duration:

- 50 minutes per session, once a day, 4 days per week, for 4 weeks.

Study period: 12 weeks.

Outcome measures: -

1. **Medical research council scale:** To measure muscle strength
2. **Fatigue severity scale:** To measure the muscle fatigue

PROCEDURE

A total of 30 individuals with type 2 diabetes mellitus who met the inclusion criteria were recruited using a purposive sample technique. The mode of therapy and method were disclosed to all individuals, and their informed consent was obtained. Before beginning the intervention, a pre-test was administered, and the subjects were separated into three groups. Group A has ten subjects, Group B has ten , and Group C is a control group with ten subjects suffering from type 2 diabetes mellitus. Group A and B were given low-level laser therapy, while the control group received resistance exercise four days a week for four weeks. Before the intervention, the subjects should be given a detailed explanation of the technique. The patient was advised to remove her jewels and put on goggles. The subjects should lie prone while treating ankle plantar flexors, supine when treating ankle dorsi flexors, and side lying when treating peroneal muscles. A towel was used to cover all areas except for the treatment area. Surface markings on the muscles were drawn, and surface area was measured for subjects in groups A and B.

GROUP – A (Photo biomodulation therapy):

The subjects receive Photo biomodulation therapy in pulsed mode for 30 minutes per session, with 10 minutes of irradiation of each muscle area, four days a week for four weeks. The scanning method of Photo biomodulation therapy is employed on the entire belly of the ankle plantar flexors, dorsi flexors, and peroneal muscles. Characteristics of Photo biomodulation therapy: The treatment lasted 30 minutes per session, with a wavelength of 808 nm, pulsed frequency, power output of 200 mW, power density of 17.85 W/cm², energy of 5 J/cm², and pulse frequency of 100 Hz.

GROUP – B (Photo biomodulation therapy):

The subjects receive Photo biomodulation therapy in pulsed mode for 30 minutes per session, with 10 minutes of irradiated of each muscle area, four days a week, for four weeks. The scan method of Photo biomodulation therapy is performed on the entire belly of the ankle plantar flexors, dorsi flexors, and peroneal muscles. Characteristics of Photo biomodulation therapy: The treatment lasted 30 minutes per session and had a wavelength of 808 nm, pulsed frequency, power output of 200 mW, power density of 17.85 W/cm², energy of 7 J/cm², and pulse frequency of 100 Hz.

GROUP – C: CONTROL GROUP: RESISTANCE TRAINING:
Resistance training is used to improve muscle strength and reduce tiredness in people with type 2 diabetes. Resistance exercise is an excellent treatment for reducing inflammation, insulin resistance, the formation of reactive oxygen species, and controlling blood sugar levels. The patient was given an explanation of the technique prior to treatment. The patient is in a protracted sitting position, and the therapist should be walking or standing. The subjects receive resistance exercise four days per week for four weeks. Thera bands are utilized to provide resistance to the ankle plantar flexors and dorsiflexors. Resistance training parameters are: intensity of 40-60% of 1RM, 8-12 repetitions, 3 sets. Treatment length of 20 minutes/sessions, with 1 minute rest period between each set.

STATISTICAL ANALYSIS:-
The statistical analysis was carried out using MS Excel 2007 and GRAPHPAD software version 20.0. Descriptive statistical data was reported as mean standard deviation and mean difference percentage.

Descriptive statistical data of subjects:-

Gender	Age	Diabetes duration	HbA1C levels	Muscle power
Male	59.2	7.24	7.67	2.78
Female	58.7	7.31	7.54	2.64

Between the groups: One way-ANOVA test was performed to assess the statistically significant difference in mean values between the groups for MRC scale and FSS scale.

Within the groups: Paired student 't' test was performed to assess the statistical difference within the groups for MRC scale and FSS scale from pre and post-test values.
The statistical significance was set at $p<0.005$ with 95% confidence intervals.

Table:1- Pre & post Mean score values of MRC scale within experimental group A:

Medical research council (MRC) scale	Pre- test value	Post- test value	t- value	P-value	Interference
Group A Mean score	2.5	3.1	3.7	0.005	Significant
Standard deviation	0.68	0.62			
Group B Mean score	2.9	4.6	6.1	0.0003	Significant
Standard deviation	0.53	0.49			
Group C Mean score	2.5	3.3	6.1	0.0003	significant
Standard deviation	0.52	0.79			

The data in table 1 shows pre and post values of Medical Research Council (MRC) scale in experimental group A, B and control C.
The pre and post mean values of MRC scale are 2.5 & 3.1 respectively. The pre and post standard deviations are 0.68 & 0.62 respectively. The t-value is 3.673, p-value is 0.005. This shows that there is significant difference in pre and post values of MRC in group A. The pre and post mean values of MRC scale are 2.9 & 4.6 respectively. The pre and post standard deviations are 0.53 & 0.49 respectively. The t-value is 6.1, p-value is 0.0003. This shows that there is more positive significant difference in pre and post values of MRC in group B. The pre and post mean values of MRC scale are 2.5 & 3.3 respectively. The pre and post standard deviations are 0.52 & 0.79 respectively. The t-value is 6.1, p-value is 0.0003. This shows that there is more positive significant difference in pre and post values of MRC in group C.

Graph:1–Graphical representation of Means of pre and post values of MRC within Group A, B & C:

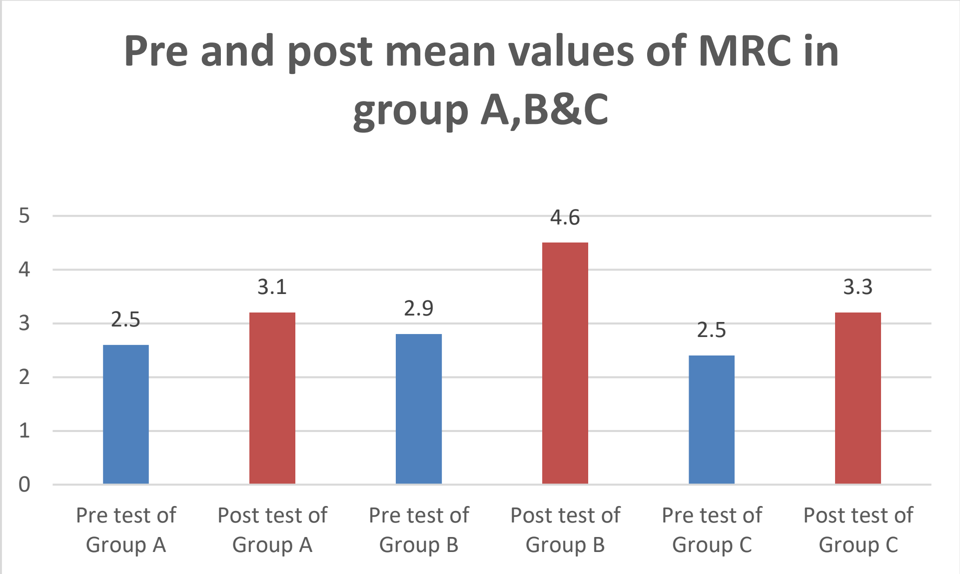


Table:2- Pre and post Mean score values of FSS scale within experimental Group A:

Fatigue severity scale (FSS)	Pre- test value	Post- test value	t- value	P-value	Interference
Group A Mean score	48.3	43.3	5.08	0.0005	Significant
Standard deviation	4.17	4.38			
Group B Mean score	43.2	33.11	6.38	0.0001	Significant
Standard deviation	4.68	5.19			
Group C Mean score	51.4	46.7	5.9	0.0003	Significant
Standard deviation	3.72	3.34			

The data in table 2 shows pre and post values of Fatigue Severity Scale (FSS) in experimental group A.
The pre and post mean values of MRC scale are 48.3 & 43.3 respectively. The pre and post standard deviations are 4.17 & 4.38 respectively. The t-value is 5.08, p-value is 0.0005. This shows that there is significant difference in pre and post values of FSS in group A. The pre and post mean values of FSS in group B are 43.2 & 33.11 respectively. The pre and post standard deviations are 4.68 & 5.19 respectively. The t-value is 6.38, p-value is 0.0001. The pre and post mean values of FSS in group C are 51.4 & 46.7 respectively. The pre and post standard deviations are 3.72 & 3.34 respectively. The t-value is 4.5.9, p- value is 0.003. This shows that there is significant difference in pre and post values of FSS in group C.

Graph:2 –Graphical representation of Means of pre and post values of FSS within Group A, B & C.

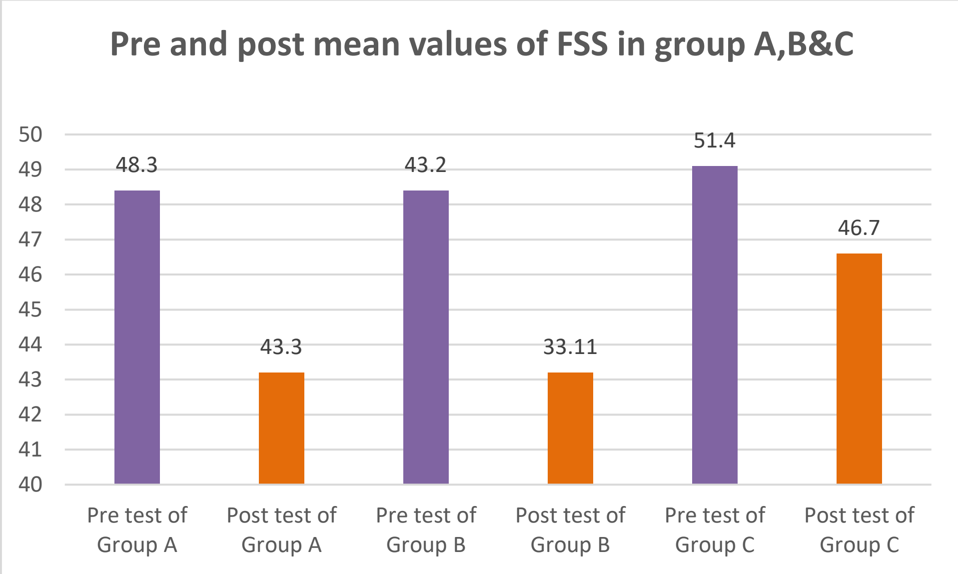


Table:3- Mean score of post-interventional values of medical research council scale(MRC) between experimental groups A, B and control groupC:

Medical research council scale (MRC)	**Group A**	**Group B**	**Group C**	**P-value**	**Interference**
Mean score	3.3	4.8	3.3	0.0002	significant
Standard deviation	0.65	0.50	0.79		

The data in table 3 shows post mean values of Medical Research Council Scale (MRC) between groups A, B &C.
The post mean values of MRC in groups A, B & C are 3.3, 4.8 and 3.3 respectively. The standard deviations are 0.65, 0.50 & 0.79 respectively. The p-value is 0.0002, which shows statistical significance. The above data shows that experimental group B shows more improvement in muscle strength when compared to experimental group A and control group C.

Graph: 3 –Graphical representation of Means of post values of MRC in experimental groups A, B and control group C.

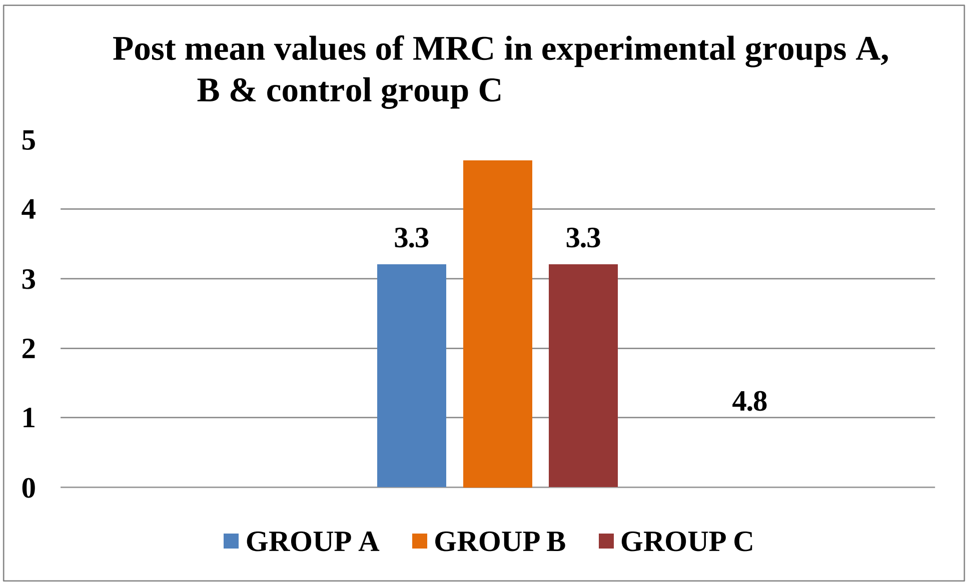
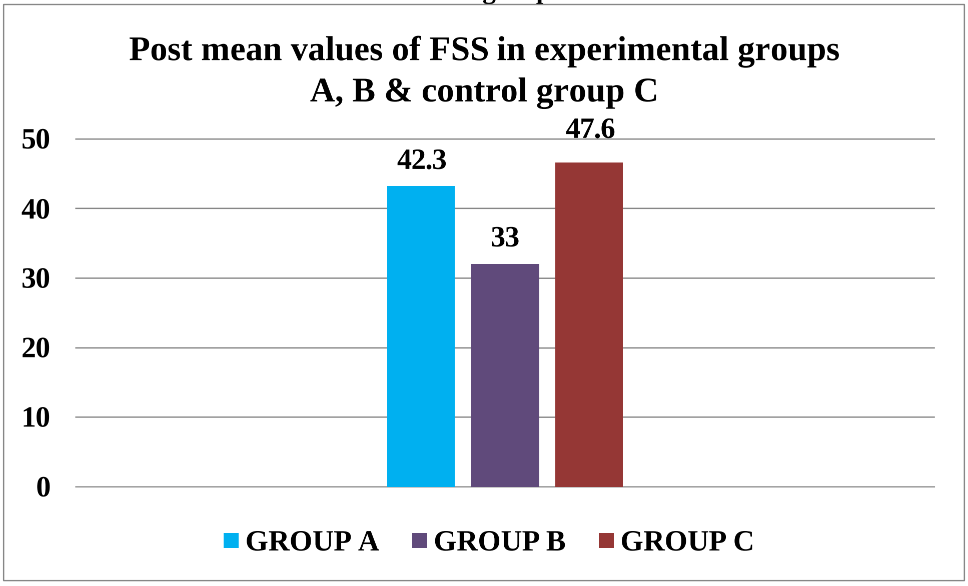


Table :4- Mean score of post values of fatigue severity scale (FSS) between experimental groups A, B and control groups C:

Fatigue severity scale (FSS)	**Group A**	**Group B**	**Group C**	**P-value**	**Interference**
Mean score	42.3	33	47.6	0.0006	significant
Standard deviation	4.38	5.19	3.34		

The data in table 4 shows post mean values of Fatigue Severity Scale (FSS) between groups A, B &C.
The post mean values of FSS in groups A, B & C are 42.3, 33 & 47.6 respectively. The standard deviations are 4.38, 5.19 & 3.34 respectively. The p-value is 0.0006, which shows statistical significance. The above data shows that experimental group B shows more reduction in fatigue when compared to experimental group A and control group C.

Graph: 4 – Graphical representation of Means of post values of FSS between experimental groups A, B and: control group C



RESULT:-

The findings of this study demonstrated a significant gain in muscle strength and a reduction in tiredness following four weeks of intervention. The post mean values of the MRC scale, which is used to measure muscle strength, were 3.3, 4.8, and 3.3 for groups A, B, and C, respectively. The p value is 0.0002, which indicates statistical significance. The post-mean data revealed that group B, treated with 7J/cm² of PBT, improved muscle strength more than group A, treated with 5J/cm² of PBT, and the control group with resistance training. The muscle strength increases in Group A and Control groups were statistically practically identical.
The post-mean values of the FSS scale, which is used to measure fatigue, were 42.3, 33, and 47.6 for groups A, B, and C, respectively. The p value is 0.0006, which indicates statistical significance. The group treated with 7J/cm² of PBT showed better resistance to fatigue, with a mean FSS decline from 42.3 to 33 when compared to the group A with 5J/cm² PBT and the control group with resistance training.

DISCUSSION:-

The results showed that four weeks of photo biomodulation therapy at varying intensities significantly enhanced the before and post-test values of muscle strength and fatigue resistance among the groups. When these groups are compared, statistical significance is observed. As a result, this study found that there is a substantial difference in the effects of different intensities of photo biomodulation therapy on muscle strength and fatigue among type 2 diabetes mellitus patients.
Although no specific mechanism for muscle weakness in people with diabetes has been determined, diabetes causes muscle strength degradation in ankle joints by affecting blood circulation in the lower limbs. Other effects include increased dryness in the dorsiflexion ankle joints and a decrease in proprioceptive receptors in these limbs.
These physiological changes are unique to diabetics and have a significant impact on their motor activity. Although muscle strength loss due to sarcopenia is frequent in the elderly, it is more common in diabetics.

Hyperglycemia degrades muscle mass by increasing the rate of breakdown, resulting in a significant reduction in muscle strength.
Muscle weariness is a complex phenomenon that can be explained using numerous hypotheses and empirical data. Among the findings from research, we highlight the depletion of energy sources such as phosphocreatine and glycogen; elevated levels of phosphate inorganic (Pi), adenosine diphosphate (ADP), Ca2+, Mg2+, H+, and lactate; decreased sensitivity of myofibrils to Ca2+; and increased production or accumulation of reactive oxygen species (ROS) and reactive nitrogen species (RNS).

PBT interacts with photoreceptors in the mitochondrial respiratory chain, increasing enzymatic activity and electron flow, which boosts ATP generation. These actions may enhance energy availability (ATP) and improve muscle performance. PBT may enhance vasodilation, which allows more oxygen and nutrients to be given to muscles, resulting in better physiological conditions for muscular contraction.

A study confirmed the effects of PBT (cluster of six 808 nm diodes) on a low-intensity physical training program (load related to the anaerobic threshold) on a stationary bicycle. The physical training was done three times a week for nine weeks straight. Five femoral quadriceps areas were irradiated with PBT for 10 seconds each. The PBT group was the only one that reduced the fatigue index of the knee extensor muscles in isokinetic dynamometry. (Vieira et al, 2012)

Silveira investigated the effects of five days of infrared PBT (904 nm) treatment in rats following traumatic gastrocnemius muscle injury. The infrared PBT greatly boosted the activity of complexes I, II, III, and IV, as well as succinate dehydrogenase. The scientists found that PBT treatment increased ATP synthesis, which may have hastened muscle recovery. Silveira et al. (2009)
Holterman demonstrated that PBT increases the number of cells per muscle fiber while also increasing muscle fiber diameter. Laser therapy also activates muscle satellite cells and regulates the expression of myogenic transcription factors including Moyd (myogenic differentiation) and myogenin (myogenic factor 4), which are hallmarks of muscular growth and hypertrophy. This indicated that PBT may aid in the production of new muscle fibers and boost muscular hypertrophy, thereby enhancing muscle strength gain, which supports our findings. (Holterman and Rudnicki et al. 2009).

Strength training or high intensity exercises (i) promotes greater energy recruitment from anaerobic metabolism (metabolic change), (ii) increases the cross-sectional area of skeletal muscle (hypertrophy) through micro-lesions, (iii) modifies the contractile characteristics of the muscle fibers (transition from type I, Ia, and Ib fibers to type IIa - structural change), and (iv) increases the recruitment, timing, and frequency of firing of muscle motor units in activity.

The current study examined the effects of various intensities of photo biomodulation therapy on muscle strength and tiredness in participants with type 2 diabetes mellitus. 30 T2DM participants with 5-10 years of diabetes duration who met the criteria were divided into three groups. Pre-intervention muscle strength and exhaustion measurements were performed using the Medical Research Council (MRC) and exhaustion Severity Scale (FSS) scales, respectively. Group A received low-level laser therapy with an intensity of 5J/cm2, an 808 nm wavelength, and a pulse frequency of 100 Hz in a pulsed mode by scanning. Group B received low-level laser therapy with an intensity of 7J/cm2, an 808 nm wavelength, and a pulse frequency of 100 Hz in a pulsed mode by scanning, whereas group C received moderate intensity resistance training with Thera bands, 8-12 repetitions, 1-3 sets. Low-level laser therapy was administered for 30 minutes, 10 minutes for each leg muscle group (plantar flexors, dorsi flexors, peroneal muscles), and weight training was given for roughly 20 minutes per session, with a one-minute rest period between sets. Treatment is administered once a day, four days a week. After four weeks of treatment, outcomes were documented using MRC and FSS.
The current study found that there is a statistically significant improvement in MRC and FSS across all groups. This is consistent with previous research conducted by Serigo Perez et al. and Patricia de Almeida et al. In this study, we used a therapy session consisting of 30 minutes of LLLT and 20 minutes of resistance training, which is a therapist-friendly strategy for an inpatient treatment program that is also cost effective and time saving for both the patient and the therapist. The post-test scores for all three groups in MRC and FSS improved.

CONCLUSION:-

This study result states that four weeks of two distinct intensities of photo biomodulation therapy in patients with type 2 diabetes mellitus resulted in significant gains in muscle strength and decreased muscle fatigue. The results showed that both 5J/cm2 and 7J/cm2 intensities of photo biomodulation therapy and resistance training improved significantly on post-interventional values within the groups; however, when compared between the groups, photo biomodulation therapy of 7J/cm2 intensity showed statistically significant improvement on muscle strength and fatigue reduction than 5J/cm2 intensity of photo biomodulation therapy and moderate intensity resistance training.

LIMITATIONS:

The study did not have a long-term follow-up. The sample size for this study was relatively limited to identify the effects of two distinct intensities of photo biomodulation therapy on muscle strength and fatigue in type 2 diabetes mellitus patients.

RECOMMENDATIONS:

Follow-up programs can be implemented to evaluate the short- and long-term effects of treatment. Additional research can be conducted to determine the impact of photo biomodulation therapy on other conditions. The effects of photo biomodulation therapy on various forms of diabetes and their complications can be investigated.

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