

The effect of low level laser therapy for pain in major muscles controlling two joints

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Background and aims: Chronic pain is a significant health care problem which is often encountered in medical institute out-patient clinics. In previous studies we have reported on the benefits of low level laser therapy (LLLT) for chronic musculoskeletal pain patients. The present study is a report on the effects of LLLT in patients with pain in major muscles which govern the motion of two joints (2-joint muscles).

Materials and methods: Over the past 5 years, 19 subjects visited our out-patient clinic with complaints of pain in 2-joint muscles (biceps brachii muscle or gastrocnemius muscle). They were treated with LLLT using a 1000 mW semi-conductor laser device delivering 20.1 J/cm² per point at 830 nm in continuous wave. Four shots were given per session (1 treatment) twice a week for 2 months (total of 16 treatments).

Results: A treatment approach modified from the methods of Shiroto and Ohshiro, was used, and the efficacy of LLLT for pain attenuation in the affected muscle was determined. After the end of the treatment regimen, excellent and good improvement was observed in 16 patients out of 19. Discussions with the patients revealed that it was important for them to learn how to modify their everyday life to avoid posture and activities of daily life that could cause them pain in the 2-joint muscles, in order to enjoy continuous benefits from the treatment.

Conclusion: The present study demonstrated that LLLT was an effective form of treatment for pain in the biceps brachii and gastrocnemius muscles. To maximize and prolong treatment efficacy, advice should be given to patients to avoid adopting any posture and activities of daily living which would cause pain in these specific muscles.

Key words: Low Level Laser Therapy • two-joint muscle pain • biceps brachii muscle • gastrocnemius muscle • postural education • advice for activities of daily living

Introduction

Muscles are attached to bones in a characteristic manner with specific insertion joints. Each muscle exerts a pull across the joint, and the action line of the muscle in relation to the joint determines the movement which will be produced within the limitations of the joint structure. There are three identifiable types of muscle contraction designated according to the change in muscle length: isometric, isotonic and eccentric contraction. In isometric contraction, no change of muscle length occurs during the contraction. Under the current definition, an isometric

contraction is one in which the external length of the muscle remains unchanged, and is called static contraction. An isotonic contraction occurs when a muscle contracts, the muscle length changes and the joint angle changes. The muscle shortens producing joint movement, this is called a shortening contraction. In eccentric contraction, the muscle is allowed to lengthen while continuing to maintain muscle tension, and this is called lengthening contraction. In the usual activities of daily living (ADL), eccentric contractions in joint movement are common. Examples include squatting or lying down, bending forward, going down stairs, stopping suddenly, placing any object down onto a surface, and so on. Muscles associated with two joints with long moment arms, even when the limbs are in the anatomical position, are for the most part large muscles which have the capability of ex-

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erting considerable force, two specific examples being the eccentric contraction of the biceps brachii and gastrocnemius muscles.

We have occasionally experienced patients with pain caused by eccentric contraction of these two-joint muscles. The present study was designed to evaluate the efficacy of low level laser therapy for chronic pain in these two specific muscles due to misuse or overuse.

Subjects and Methods

1: Subjects

Nineteen patients (9 males and 10 females) between the age of 20 and 83 (average age 50.2 ± 18.8) took part in this study. All subjects were out-patients who visited the rehabilitation department of our hospital between April, 2012 and March, 2017 (**Table 1**). All patients visited the out-patient clinic within one week of onset of pain. They all had a definitive diagnosis of muscle tenderness in the biceps brachii (11 patients) or gastrocnemius muscles (8 patients) for which surgery was not indicated. Diagnosis

was based on physical symptoms: complaints caused by chronic sports trauma and misuse or overuse of eccentric muscle contraction in the activities of daily life.

2: Methods

We used a 1000 mW semiconductor laser device, the MDL 2001 (Matsushita Electric Corporation, Tokyo Japan), delivering 830 nm in continuous wave. We treated the 19 patients with the laser system for each session at an energy density per 30 s treatment of 20.1 J/cm^2 (**Table 2**). Four points were irradiated (**Figure 1**) per session (comprising 1 treatment) twice a week for 2 months (total 16 treatments). No medication was used, because in the present study we wished to assess the effectiveness of the LLLT intervention on its own. The study was conducted under the principles of the Declaration of Helsinki (2013). The trial was conducted with the approval of the Ethics Committee of the Toho University School of Medicine, Institutional Review Board (IRB). The purpose and potential outcomes of the trial were explained to all participants, and they gave written informed consent to participate the study.

Table 1: Patient demographics, diagnosis, VAS scores and Evaluation

Cases	Age	Sex	Diagnosis	Pre.VAS score	Post VAS score	Improvement of VAS Score	Evaluation
1	58	M	BB	70	65	5	P
2	50	M	BB	70	55	15	F
3	83	M	BB	100	50	50	E
4	24	M	BB	70	50	20	G
5	62	F	BB	90	70	20	E
6	23	F	BB	100	40	60	E
7	43	M	BB	90	50	40	E
8	67	F	BB	50	30	20	G
9	70	M	BB	50	20	30	G
10	59	F	BB	100	70	30	G
11	45	M	BB	75	65	10	P
12	55	F	G	70	30	40	E
13	67	F	G	80	20	60	E
14	33	F	G	60	10	50	E
15	57	F	G	70	30	40	E
16	25	M	G	70	40	30	G
17	73	F	G	70	30	40	E
18	20	F	G	50	5	45	E
19	40	M	G	90	20	70	E

VAS: Visual Analogue Scale BB: Biceps brachii muscle
Evaluation: Table 3 G: Gastrocnemius muscle

Evaluation of Muscle Pain Attenuation

A treatment approach modified from the methods of Shirotto and Ohshiro, was used to determine the effects of LLLT for the pain attenuation in the 2-joint muscles.¹⁾ Pain was scored using a visual analog scale (VAS) where 100 was the worst possible pain and zero was no pain.

Lifestyle guidance for the patients:

Patients were advised to continue their normal activities of daily living (ADL). However, we give them written advice sheets on maintaining a good posture to avoid any trigger position related with pain in eccentric muscle contraction in everyday life.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics, version 24, IBM Company. The Wilcoxon signed rank test was applied to compare the VAS scores before and after LLLT. The level of significance was set at ≤ 0.05 .

Results

Evaluation of pain relief efficacy in the biceps brachii and gastrocnemius muscles

The VAS scores at baseline and the final assessment are shown in **Table 1** and summarized in **Table 3**. The results were Excellent in 11 patients, Good in 5, Fair in 1, Poor in 2 and Worse in 0. No side effects were noted and pain was not exacerbated in any patient. The average VAS score before treatment 75.0 ± 16.4 , and after treatment the average VAS score was 39.7 ± 20.1 .

Results of statistical analysis

The VAS score after LLLT was highly significantly lower than the score before LLLT (0.0001).

Patient Lifestyle Guidance:

Patients were advised to avoid adopting any posture that could induce pain, and we counselled the patients how

Table 2: Specification and characteristics of the LLLT device used in the present study

Laser Element	: Laser Semiconductor Diode Ga-Al-As: Gallium -Aluminum-Arsenide
Model & Manufacturer	: MDL9001 (#) Matsushita Electric Corporation, Tokyo, Japan
Wavelength	: 830 nm $\pm$ 15 nm
Output	: 1000 mW $\pm$ 20%
Mode	: Continuous wave mode Contact mode with positive pressure
Irradiation area	: diameter: 14 mm: treatment area, 1.5 cm ²
Irradiation time	: 30 s
Energy density	: 20.1 J/cm ²
Power supply	: 100 AC, 50-60 Hz

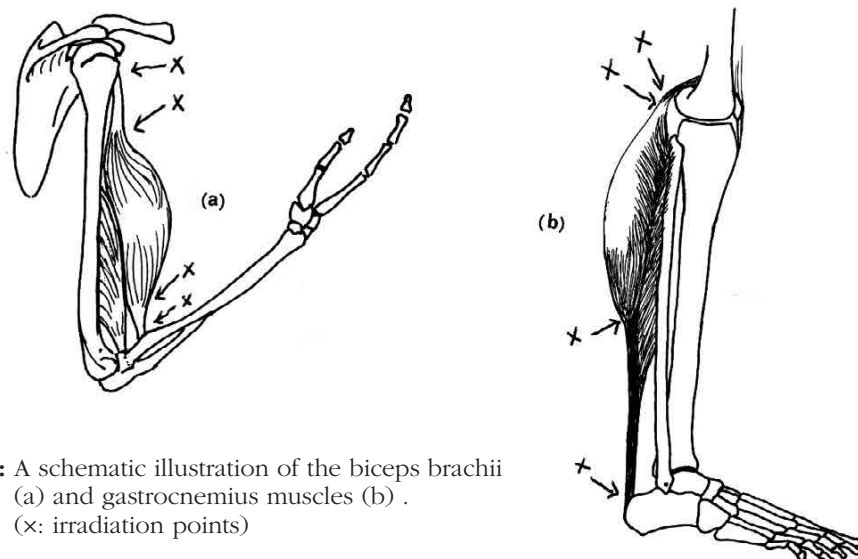


Figure1: A schematic illustration of the biceps brachii (a) and gastrocnemius muscles (b) .
(x: irradiation points)

to avoid incorrect positions which could exacerbate discomfort or pain in the biceps brachii and gastrocnemius muscles during their normal ADL, as already mentioned in the Subjects and Methods. After discussions with the patients, it was reported in all cases that the lifestyle guidance was well understood, and the advice that was given was realized. However, in the score-sheet filled out by patients after the treatment, there were some patients who did not precisely follow the lifestyle guidelines, therefore statistical analysis was not performed on this parameter.

Discussion

The attachments of a skeletal muscle are its origin and insertion; anatomically the origin is the more proximal attachment and the insertion is the more distal attachment. A single joint muscle (SJM) involves one joint, on the other hand, a two-joint muscle (TJM) extend over two joints (referred to as 2-joint muscles in the present study). SJMs affect one joint, and TJMs affect two joints of the skeleton affecting their work efficiency, but sometimes we have some cases where chronic pain has resulted from the overuse, misuse or incomplete sport injury involving 2-joint muscles. For example, when the upper arm is moved forward, tension developing in the biceps brachii contributes, simultaneously, to flexing the elbow and rotating the forearm. When the knee is moved backward, tension in the gastrocnemius contributes, simultaneously, to flexion of the knee and dorsiflexion of ankle joint^{2,3)}.

Therefore, the complex mechanics associated with TJM action compared with SJM involvement are obvious. Because of these complex rotational forces, cases of chronic pain associated with TJM misuse/overuse are not uncommon. As mentioned above, we experience two-joint muscle pain in daily life. In many cases, pain can

develop in the biceps brachii (BB) muscle and gastrocnemius (G) muscle pain due to overuse, misuse, a variety of exercise activities, sports and so on. From our experience, in these chronic cases of BB and G muscle pain the site most prone to pain has been the transitional portion between the muscle and tendon.

In general, this site of interest is located close to the area where the muscle is attached to the bone. From the standpoint of posture control, when the posture is such that the body fails to follow the line denoting its center of gravity, chronic pain is more liable to develop in the muscles involved. There has been a lot of basic research^{4, 5, 6)}, and many clinical studies^{7, 8, 9, 10, 11, 12, 13)} carried out involving LLLT. Some previous reports have discussed the type of LLLT device¹⁴⁾, wavelength-specific benefits¹⁵⁾ and evaluation of treatment methods. Recently, basic research on LLLT is gaining validity. As an example of this, if a PubMed search is carried out using ‘LLLT’ as the keyword, over 5,700 results will be displayed.

There are various possible explanations for the positive effects of LLLT treatment^{16, 17, 18)}. The authors believe that a rise in the pain threshold, improved blood flow and regeneration of the compromised structure of 2-joint muscle are the main contributing factors^{19, 20)}.

In this study, we treated the disease with LLLT irradiation, as one of the tools available in physical therapy. LLLT is simple and easy to administer without any side effects. Regarding the evaluation of pain, a statistically significant effect was observed in the VAS scores after irradiation ($p < 0.0001$).

However, one limitation of this cross-sectional study was the lack of a demographically-matched control and or placebo (sham irradiation) group. Another limitation is the lack of a long-term follow-up after the final treatment session to assess the latency of the efficacy. To validate the results of this study, such controlled and placebo studies with a long-term follow-up are required and warranted in the future.

Conclusion

The present study demonstrated that LLLT was an effective form of treatment for 2-joint muscle pain. Patients should be advised regarding adopting an inappropriate posture and inappropriate activities of daily living which could result in developing 2-joint muscle pain, or exacerbating such preexisting pain. Therefore, for patients to continue to reap the benefits of LLLT intervention, we discovered that education regarding posture during patients’ ADL was also very important.

Table 3: Evaluation of the VAS score

Evaluation	Improvement of the VAS score after LLLT	Number of Cases
•Excellent (E)	35 and over	11
•Good (G)	20—34	5
•Fair (F)	15—19	1
•Poor (P)	14 or under	2
•Worse (W)		0

Evaluation of efficacy with the VAS score: most severe pain scored at 100, pain free scored at zero.

See Table 1 for individual scores and evaluations.

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