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Case Report

Modulation of Gluteus Medius Strength by Yang Qiao Mai Stimulation: A Multiple Case Report

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Abstract

Yang Qiao Mai, one of the eight channels known as extraordinary meridians, is used in traditional Chinese medicine (TCM) to relieve tension in the lateral muscles of the legs.

According to TCM, each extraordinary vessel has main points, coalescent points, and one single master point (BL62 Shenmai for Yang Qiao Mai), which can influence the entire path of the meridian.

We performed a test which involved measuring the changes in abduction strength of the gluteus medius following stimulation with a new type of photobiomodulation device, which delivers a very low level of modulated light on the BL62 Shenmai acupuncture point. Twenty-two healthy volunteers were measured, stimulated, and the measurement repeated 30 minutes after the first measurement. In addition to showing a regulatory effect of the stimulation, the test confirmed that a modulated red-light emission with a stimulus duration of 20 s for a total delivered energy of 0.35 mJ can induce an acupuncture-like response, even in the short term. The difference between the two body sides generally results as being around 6 Kg: this figure appears to be a physiological limit, probably due to an anatomical compensation of the body asymmetries.

These results offer a new insight into the interpretation of the signaling process along the meridians, and appears to involve the return to homeostasis of the extracellular soft tissue matrix promoted by the photon flow.

Keywords: ***Yang Qiao Mai, photobiomodulation, acupuncture, lower limb tightness, Trendelenburg test***

Introduction

The purpose of the study was twofold:

1. To assess the effectiveness of Yang Qiao Mai stimulation to treat a gluteus medius muscle asymmetry [1] which affects both static and dynamic stability [2];
2. To assess whether the photobiomodulation stimulus applied to the Yang Qiao Mai entry point provokes a beneficial effect comparable to that attainable via the traditional needling technique. Similar results could cast a new light on the action mechanism of the meridian, claimed by some authors to act as a mechanical stimulus through the fascia.

The Yang Qiao Mai

The Yang Heel Vessel or Yang Qiao Mai, one of eight extraordinary meridians (EEM), relates to the movement of the lower extremities, and to the left and right sides of the body. Its function is to promote the agility and motion of the lower limbs, and it runs up the outside of the lower limb (from the heel to the pelvis), continuing up the side of the chest. [3,4].(**See Figure 1**).

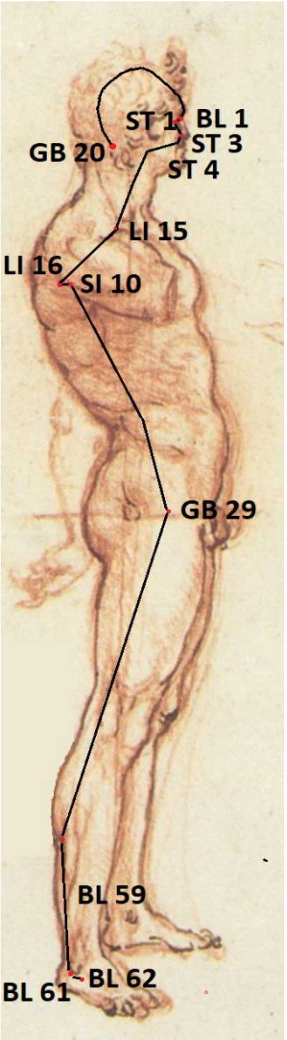

Figure 1: The Yang Qiao Mai
Drawing of the human figure courtesy of Leonardo da Vinci

Like all eight extraordinary meridians (except Du Mai and Ren Mai), the Yang Qiao has no specific points, sharing them with the twelve regular meridians (known as "main points"). Like all the eight extraordinary meridians, it has main points located on the regular meridian, coalescent points (where they meet other regular meridians) and one master point, or opening point. Each of the opening points activates two different regular meridians, and treats the indications of these meridians, as well as its own specific indications. Du Mai SI-3 Houxi, for example, treats the symptoms and indications of the small intestine meridian, while Bl-62 Shenmai treats the indications of the bladder meridian. Du Mai therefore not only addresses its own meridian imbalances, but can also address more complicated issues manifesting in the small intestine and bladder meridians [5]. The Yang Qiao Mai begins at Shenmai BL 62 and descends to Pucan BL 61, before ascending the lateral aspect of the lower leg to arrive at Fuyang BL 59, continuing up the leg to the thigh and lateral side of the hip to arrive at Juliao GB 29. From Juliao, the meridian travels up the lateral aspect of the torso, veering around the posterior aspect of the shoulder to meet Naoshu SI 10, Jianyu LI 15, then Jugu LI 16. From the shoulder region, the meridian runs along the lateral aspect of the neck to meet at the face in the region of Dicang ST 4, Juliao ST 3, Chengqi ST 1 then Jingming BL 1, where it meets the Yin Qiao Mai. From Jingming, the meridian curves around the side of the head to meet Fengchi GB 20, before entering the brain.

The Yang Qiao Mai affects the functions of the lower limb muscles and tendons. For the historical author Wang Shu He [6], as stated on the Nan Jing [7], the Yang Qiao Mai should be stimulated in the event of tension and tightness of the lateral muscles of the legs above the malleoli: "In Yang Qiao

Mai there is tightness of the Yang side, and looseness of the Yin side". Considering the weakness of the gluteus medius muscle (See Figure 2) as a symptom of chronic tension, we selected the Yang Qiao Mai main point GB 29 Juliao, which has an anatomical overlap with the trigger point of the gluteus medius itself, and decided to treat the master point BL62 Shenmai to increase the strength of the gluteus medius muscle.

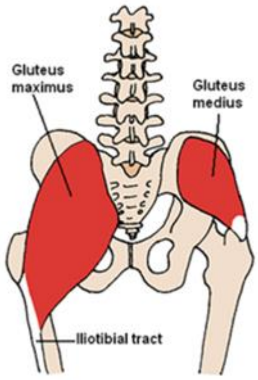

Figure 2: Muscle anatomy
Gluteus Medius and Maximus: evident the functional role of Gluteus Medius in the lower limb abduction movement

The gluteus medius strength test

Hip abductor weakness is typically evaluated using the Trendelenburg test [8,9]. The test requires the patient to stand on one leg for 30 seconds without leaning to one side, holding on to something for support if balance is an issue. The therapist observes the patient to see if the pelvis stays level during the single-leg stance (**see Figure 3**).

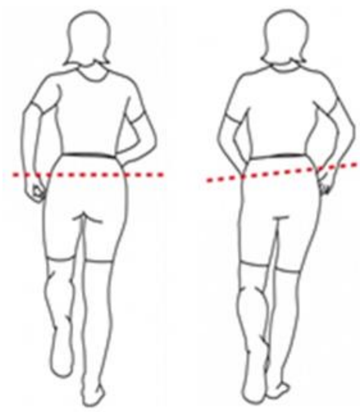

Figure 3: The Trendelenburg Test
Please note the rotation of the hips' axis during walk

Like many physiotherapy tests, the Trendelenburg involves subjective evaluation by the therapist. In addition, the patient's fitness level may also affect the result, prompting us to opt for an instrumental measurement rather than a subjective assessment.

A popular chiropractor test derived from the Ober's test can be used to evaluate a tight, contracted or inflamed gluteus medius. At the maximal angle of abduction, the therapist presses the extended leg downwards as the patient pushes upwards against the resistance exerted by the therapist. A lack of force generally indicates a hip mobility deficit, and a significant difference in leg abduction strength between the two limbs would certainly affect stability, both static and dynamic.

Materials and Methods

The sample

The sample consisted of 22 healthy volunteers (14 F + 8 M) with a mean age of 32.6 years, a mean height of 171.5 cm, and a mean weight 66.4 kg. In terms of individual clinical histories, however, the sample varied widely (see Table 1): The tested subjects were volunteers that gave their informed written consent.

Table 1: The sample

REF	SEX (M/F)	AGE (yrs)	HEIGHT (cm)	WEIGHT (Kg)	Medical history
ADC	F	46	171	65	Bilateral chondropathy, 3 vertebral protrusions, scoliosis (30°), plantar fascitis
AS	F	33	163	52	Occasional dorsal pain
ST	M	30	184	85	Occlusion deficit
AG	F	45	172	54	Cervical protrusions, paresthesias, scoliosis, acromioclavicular dysfunction, dizziness
FI	F	47	170	67	Lumbar pain
EF	M	24	190	82	Occasional cervical pain
JR	M	25	178	70	Occasional cervical pain
EF	F	36	160	49	Nothing of clinical significance
TC	F	40	173	87	Post traumatic muscular lesion keloids
AM	F	25	170	70	Thoracic scoliosis, coxalgia
SR	F	32	168	58	Appendicectomy
GS	F	41	150	47	Bowel pain, dizziness, radial bilateral paresthesias
LN	F	24	174	65	Nothing of clinical significance
FM	M	28	175	64	Traumatic lesion to the right knee cartilage
BB	F	38	168	63	Cervical discopathy, slight lumbar scoliosis
SS	M	47	176	78	Cranial trauma, radial head fracture, right rotator cuff lesion
GDR	M	21	186	75	Nothing of clinical significance
MC	M	21	172	63	Nothing of clinical significance
SC	F	27	153	53	Nothing of clinical significance
IDG	F	27	168	65	Nothing of clinical significance
GZ	M	28	190	95	Right clavicula infraction, left Achilles's tendinosis, semitendinosus muscle distraction
ES	F	33	163	55	Nothing of clinical significance

Libralux®

The Libralux® is a class IIa CE certified medical device which emits photobiostimulation [10-12], laser light modulated according to a patented combination of square waves. The laser provides red-light emission (λ=650nm) with a peak output of 7 mW and an average power of 0.0175 mW, thanks to a combined duty cycle of 0.25%. The application performed consisted of 20 seconds of radiation on each acupoint, emitting a dose of energy over 50,000 times smaller than any conventional low power laser applied in medical treatments, interacting with the redox cycle of the proteoglycans of the extracellular soft tissue matrix present in the acupuncture point funnels [13]. Remarkable similarities have been observed between the photobiostimulation and conventional needle acupuncture of the same points to treat musculoskeletal conditions (stimulation of combinations of well-known acupuncture points according to standardized protocols) [14] some ophthalmological conditions (treatments of amblyopia [15], eye blood perfusion in wide angle glaucoma [16], and the effects of LU7 Lieque stimulation on respiration depth and frequency [17]).

Handheld dynamometer

A handheld dynamometer (FGP, Verona, Italy) was used to measure the force of the gluteus medius during the manual muscle test. The dynamometer has a load cell (full-scale 90kg) and can be operated using one hand only. Once the operator has positioned the device on the distal part of the tested joint/segment, the patient pushes upwards against it as the operator applies an opposing downwards force. The instrument measures the force applied between operator and patient, and sends the results to a PC via Bluetooth.

Measurement technique

The test procedure was explained and demonstrated to each subject in advance. The patients were asked to lie on their side on the treatment table, keeping the bottom leg flexed for support, and to abduct the top leg as far as possible. The operator then applied downward pressure with the dynamometer to the external side of the leg, midway between the knee and the ankle, while the patient exerted the maximal possible resistance against the downwards pressure exerted by the operator. The maximum exerted power was recorded for each leg, and the measurement repeated two minutes after stimulation to assess the effect of the stimulus itself.

Applied stimulation

Libralux stimulus was applied to the BL62 acupoint of the weaker leg immediately after the baseline measurements, and to the weaker leg once this had been identified. The stimulus was applied for 20 seconds (applied energy 0.35 mJ at a density of 3.5 mJ/cm2).

STRICTA

The STRICTA[18] checklist is included (See Table 2)

Table 2: STRICTA 2010 checklist of information to include when reporting interventions in a clinical trial of acupuncture (Expansion of Item 5 from CONSORT 2010 checklist)

Item	Detail
1. Acupuncture rationale	1a) **Style of acupuncture:** Traditional Chinese Medicine
	1b) **Reasoning for treatment provided:** Yang Qiao Mai regulates the ascending and descending of Yang Qi and the movement of the lower limbs
	1c) **Extent to which treatment was varied:** All subjects received only a **BL** 62 Shenmai (Yang Qiao Mai Opening point)
2. Details of needling	2a) **Number of insertions:** One – single session
	2b) **Stimulated point:** BL 62 omolateral to the less strong abducting leg
	2c) **Depth of insertion:** NA – Photobiomodulation
	2d) **Response sought:** increase of abduction strength
	2e) **Needle stimulation:** ultra-low power red light (650 nm) pulsed radiation (100; Duty Cycle 1% AND 7.35; Duty Cycle 50% AND 1 Hz; Duty Cycle 50%) for a mean radiance of 0.01 mW/cm^2 applied for 20 sec
	2f) **Needle retention time**: NA, the exposure lasted 20 sec
	2g) **Needle type:** NA
3. Treatment regimen	3a) **Number of treatment sessions**: One
	3b) **Frequency and duration of treatment sessions**: One
4. Other components of treatment	4a) **Details of other interventions administered to the acupuncture group**: None
	4b) **Setting and context of treatment, including instructions to practitioners, and information and explanations to patients:** an increase of lower limb abduction strength and a re-balancing of strength in both limbs was expected: both subjects and acupuncturist applying the stim were made aware of the expected results
5. Practitioner background	5) **Description of participating acupuncturists**: one qualified acupuncturist
6. Control or comparator interventions	6a) **Rationale for the control or comparator**: the lower limb abduction strength was measured with a dynamometer applied just above the external malleolus
	6b) **Precise description of the control or comparator**: NA, the test was not blind, no sham or control were included.

Results and Discussion

Measurements and results

The measurement data is given in Table 3, while the absolute differences between the recorded measurements are given in Table 4.

Table 3: Raw strength readings (kg)

REF	BEFORE		AFTER	
	R LEG	L LEG	R LEG	L LEG
ADC	22.80	16.80	25.60	19.60
AS	25.50	23.70	26.10	21.30
ST	27.10	13.70	29.60	24.10
AG	27.20	14.40	29.30	22.10
FI	30.10	27.60	25.90	25.90
EF	26.00	23.60	27.30	23.60
JR	26.70	19.30	27.10	23.90
EF	23.20	19.50	21.70	18.70
TC	32.00	32.80	31.70	33.10
AM	23.20	26.10	22.90	21.90
SR	19.10	24.08	24.00	20.05
GS	27.10	26.80	28.10	27.30
LN	23.10	16.40	21.01	26.10
FM	28.90	19.10	25.30	18.90
BB	26.70	25.70	28.90	26.90
SS	27.10	26.00	29.20	23.70
GDR	24.30	19.10	25.20	19.50
MC	22.00	18.80	20.70	15.90
SC	24.90	20.80	26.90	20.70
IDG	22.30	15.50	22.40	17.60
GZ	21.20	19.50	24.90	21.20
ES	24.00	22.90	23.50	24.80
MEAN	**25.20**	**21.46**	**25.79**	**22.58**
Std.Dev.	**3.06**	**4.87**	**3.00**	**3.88**
MEDIAN	**25.20**	**20.15**	**25.75**	**22.00**
Variation coeff (%)	**12.14**	**22.69**	**11.63**	**17.18**

Table 4: Differences between legs (kg)

REF	BEFORE	AFTER
ADC	6.00	6.00
AS	1.80	4.80
ST	13.40	5.50
AG	12.80	7.20
FI	2.50	0.00
EF	2.40	3.70
JR	7.40	3.20
EF	3.70	3.00
TC	0.80	1.40
AM	2.90	1.00
SR	4.98	3.95
GS	0.30	0.80
LN	6.70	5.09
FM	9.80	6.40
BB	1.00	2.00
SS	1.10	5.50
GDR	5.20	5.70
MC	3.20	4.80
SC	4.10	6.20
IDG	6.80	4.80
GZ	1.70	3.70
ES	1.10	1.30
MEAN	**4.53**	**3.91**
Std.Dev.	**3.74**	**2.07**
MEDIAN	**3.45**	**4.375**
Variation coeff (%)	**82.56**	**52.94**

Given that the first objective of the test was to observe the induced modifications to abduction resistance, if any, we decided to plot the measurements in a separate graph, where the X axis consists of the values read before treatment, while those read after the treatment are plotted on the Y axis. It is a graph inspired by the "IntraOcular Trauma test", a criterion coined by Joe Berkson at the Mayo Clinic: "Plot the data, and if the result hits you between the eyes, it's significant".

Unfortunately, the graph showed only a slight reduction to both legs, independently of the side treated (Figures 4 and 5)

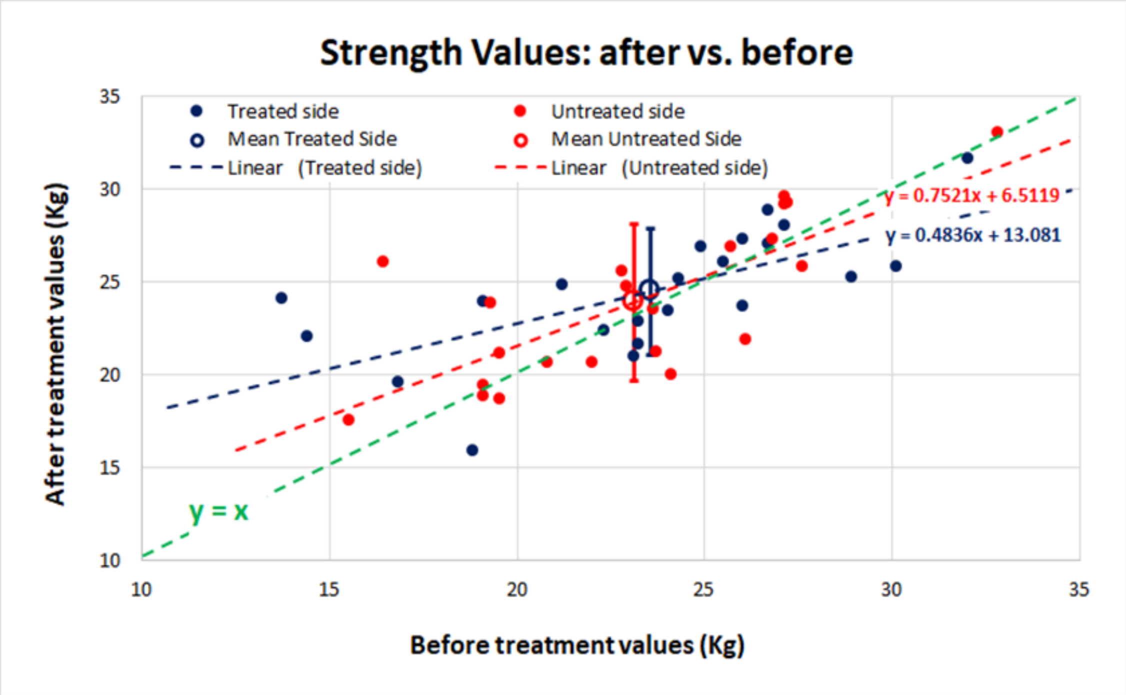

Figure 4: Leg strength modifications

The plot shows, for each lower limb, treated (blue color) and untreated (red color), the measurement values after (y axis) vs before (x axis). The "no change" line (green color) shows that the differences are rather small, slightly more evident for the treated side (blue dotted line)

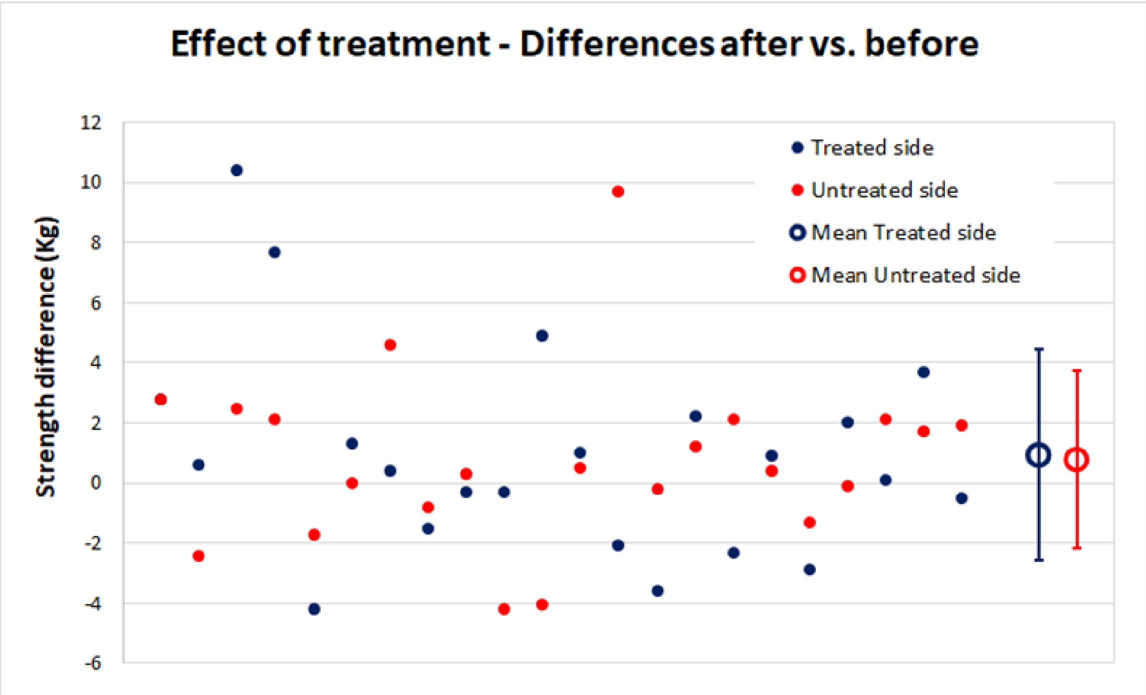

Figure 5: Leg strength modifications

The plot shows the differences of measurements measured on each limb before and after treatment

Strength imbalance

Following a previous analysis of the effects of a laser acupuncture treatment on eye blood flow in wide-angle glaucoma patients, we formed the hypothesis that the treatment might improve the balance between the two body sides, as also suggested by the physiology of the extraordinary meridians.

It appears that the difference tends to stabilize around a value of 6 Kg, which may be physiological (**Figure 6**).

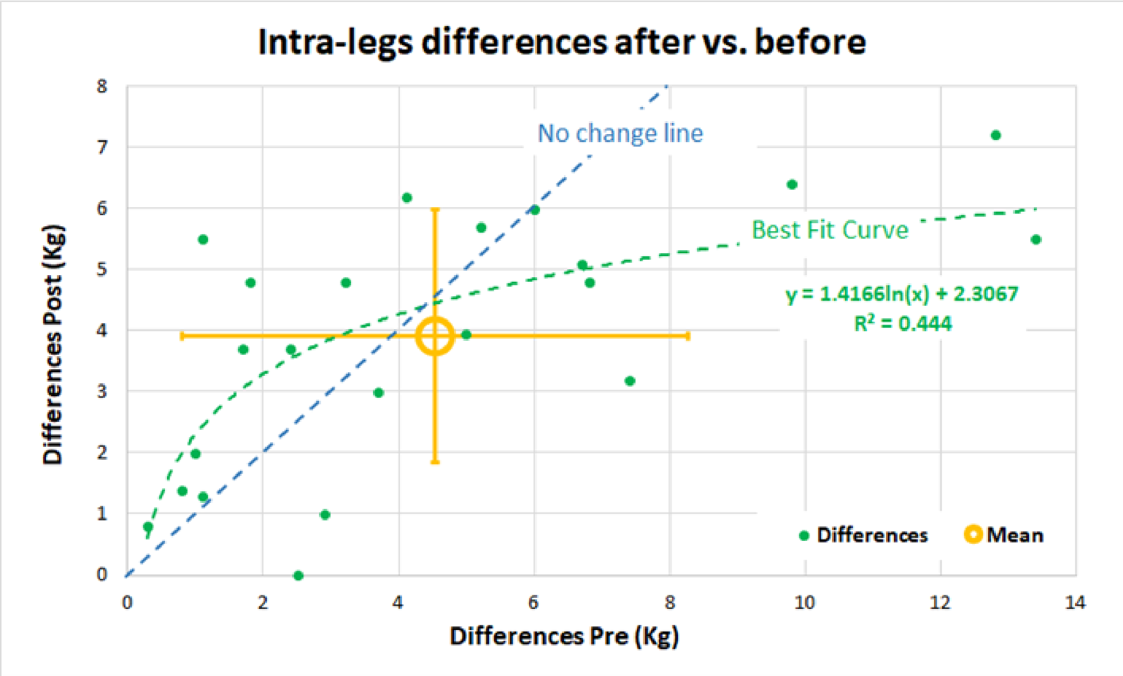

Figure 6: Differences Post vs. Pre (Absolute Values)

Although scattered, the plotted data show a logarithmic best fit curve apparently indicating tendency to stabilize at a 6 Kg Value. At any rate, the best fit curve lies well under the no change line (Difference before = Difference after) plotted in blue colour.

As previously stated, the results were not statistically relevant, mainly because the asymmetry at the first measurement was under 6 Kg for the majority of the sample, the value we propose as a potential physiological threshold due to compensated anatomical asymmetries.

Discussion

About this test

Although the results are encouraging, the sample consisted mainly of healthy or compensated individuals – some of them athletes – who showed only a slight difference between the two sides of the body, and any new test should be performed on a population with more severe anomalies.

The decision to perform the second test two minutes after treatment was based on the experiences acquired through the clinical application of Libralux. Any new test should consist of two measurements performed two and ten minutes after stimulation. A still unexpected delay in the effect could provide additional information on the physiological action mechanism.

About the myofascial meridians

Myofascial meridians are, by their very nature, a cross-link between the meridians and the fascia [19]; they borrow acupoints from the standard meridians, and constitute a sort of anastomotic bridge between different standard meridians [20] running along the fascia and affecting musculoskeletal conditions specifically. In addition to the specific clinical value of the test itself, the applied stimulus may also provide new insights into the underlying transmission mechanisms: indeed, the applied stimulus, minimally invasive and consisting of an extremely low level of energy, differs significantly from the mechanical stress applied by the traditional needle which "grasps" the fascia fibres.

About the Yang Qiao Mai

The GB29 Juliao lies along the Yang Qiao Mai over the hip joint, anatomically over the tensor fasciae latae, and more deeply over the gluteus medius and minimus. According to Travell & Simons [21] the position of the classical "trigger point" of the gluteus medius appears to be almost superimposable to GB 29. The role of the extraordinary meridian consists of providing a reservoir of Qi and blood to support the demands of the associated meridians (the "coldness" of GB 29) [22].

About the action mechanism of photobiomodulation acupuncture

Acupuncture forms part of traditional Chinese medicine, a discipline dating back at least 2,200 years, and is essentially based on the concept of energy flow throughout the body, in continuity with the energy flow of the universe.

Acupuncture is based on the belief that energy flows through the body in a network of channels called meridians. Along these meridians lie acupuncture points, which can be stimulated to affect this energy flow.

Acupuncture points have been identified using anatomical and histological criteria [23,24], and evidence points to a relationship between acupuncture points, fascia perforations and a significantly increased concentration of free nerve terminations and artery capillaries in an ECM-rich environment. The latter may be the reason for the higher electrical conductivity observed at the tissues underlying and surrounding acupuncture points [25].

Acupuncture points also appear to show greater laser light absorption than surrounding tissues [26]. The measured resonance frequencies of the meridians (**Figure 7**) were adopted for the Libralux [13].

The issue of meridians, however, warrants a number of considerations:

- In classical acupuncture practice, why do patients report what is known as the "de-qi sensation", even at a distance from the treated acupuncture point? Acupuncture practitioners are familiar with these sensations, often reported as "strange" feelings of "pins and needles", "numbness" or sensations of heat.

- Could the grasping of the fibres when manipulating the needle be associated with a mechanosensing phenomenon?
- What is the transmission medium of the signal when we perform electro-acupuncture?
- And when we perform laser-acupuncture?

There are several chief issues:

- What is the transducing element capable of transforming the stimulation into an acupunctural signal?
- What is the transmission medium into the meridian?
- Why is the stimulus which travels into the meridian network capable of producing the specific effect?

In addition to the reflections proposed regarding a likely model of ECM metabolism, time of response to stimulation provides a clue as to its probable nature: in the case of a nervous stimulus, we should expect a few milliseconds, while in the event of a chemical modification, a longer interval would be expected.

Our experiences with a low-level laser (stimulation of the GB34 Yangligquan contralateral to the upper trapezius oedema) showed the effect in 3 minutes, with a reduction in edema thickness. The mechanical pressure hyperalgesia measured with a pressure algometer was also strongly reduced [27]. (**See Figure 8**).

We firmly believe that the transmission medium is not the fascia itself but the extracellular soft tissue matrix (ECM) [28], through which there is a physiological flow of photons resulting from the redox cycle of the ECM proteoglycans in their task of delivering O- ions to cell metabolic activities: this flow is modified by the SOL/GEL status of the ECM itself.

“The proteoglycan molecules in connective tissue typically form a highly hydrated, gel like “ground substance” in which the fibrous proteins are embedded. The polysaccharide gel resists compressive force on the matrix while permitting the rapid diffusion of nutrients, metabolites and hormones between the blood and the tissue cells” [29]

The thickness, viscosity and pH of the ECM deviate from their normal values when in GEL status [30], indeed manual medicine practitioners report resistance during the “pincer-rouler” of myalgic tissues. ECM modifications may also affect volume transmission in the synaptic spaces, causing specific vasomotion reflexes.

While a correlation between the “de-qi sensation”, “needle grasp” phenomena and mechanical deformation of the fasciae tissue [31] has been proposed, we hypothesize a primary involvement of the neuroanatomical organization of the free ending fibres (interoceptive unmyelinated afferents fibres located in the ECM) which carry out the downstream signalling following the acupoint stimulus, propagating the “de-qi sensation” along the channel.

This hydraulic-type transmission [32] consistent with the photon cascade through the ECM certainly appears more likely than a mechanical transmission mechanism, since not all acupoints are located on the fascia tissue planes, while the ECM is distributed throughout the entire body: while the ECM might be the primordial unshaped structure of the fascia, this model contemplates at the same time the fascia model such as the neurophysiological model.

The nature of the meridians themselves appears more elusive, although a number of interesting studies suggest that the ECM may be the ubiquitous “organ” through which information is exchanged or shared among cells [33-35], from the embryological phase (before the germ layers differentiate to form the nervous system) onwards.

Conclusions

Clinical

This study has shown that the stimulation of the BL62 Shenmen acupoint can modify the strength of the gluteus medius muscle to improve balance control. However, a further study on a larger sample of dysfunctional subjects is needed to draw reliable conclusions with regard to the clinical application of the treatment, especially in defining:

1. Whether treatment should be performed on one side only (homo or contralateral to the defective side) or bilateral;
2. Whether the treatment should also involve the SI 3 Houxi acupoint (homo/contralateral or bilateral)
3. The posology of the applications (how many and at what time interval).

Yang Qiao Mai

Treatment with ultra-low-level modulated red light stimulates the meridian and gives observable effects.

The results show that the effects of the treatment are proportional to the imbalance between the two sides of the body, indicating that the stimulus regulates the patient’s strength rather than simply increasing it, resulting in improved balance.

Signal transmission through the acupuncture meridians

The stimulus applied in this study, consisting of a negligible modulated light energy source resulting in a rapid physiological response, reinforces the hypothesis of a photochemical mechanism whose rhythmical occurrence forms the basis of the homeostatic process. Any deviation from these conditions modifies the physiological response through peripheral vasomotion control and possibly central autonomic functions.

Ethics approval and consent to participate

All participants were volunteers that did subscribe a written informed consent to take part to this test.

Data Availability

The full spreadsheet with all the test data can be made available upon request to the corresponding author.

Conflicts of Interest

MG is the inventor of Libralux and minority shareholder of Fremslife that produces and distributes the device. All the other authors declare that there is no conflict of interest regarding the publication of this paper.”

Funding Statement

No funding was given to support this trial.

Authors' contributions

GB, EB and FS designed the test; MG processed the data and edited the manuscript; LR performed the strength test; GBL applied the stimulation; AP supervised the test. All authors take part in the preparation of the manuscript.

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