

Original Research

Heart Rate Variability during Acupuncture Treatment of Lumbosacral PainYan Yang^{1,2,†}, Gerhard Litscher^{1,2,†,*}, Zemin Sheng^{2,3}, Lu Wang^{1,2}

1. Research Unit of Biomedical Engineering in Anesthesia and Intensive Care Medicine, Research Unit for Complementary and Integrative Laser Medicine, and Traditional Chinese Medicine (TCM) Research Center Graz, Medical University of Graz, 8036 Graz, Austria; E-Mails: grace.yang123@outlook.com; gerhard.litscher@medunigraz.at; lu.wang@medunigraz.at
2. Heilongjiang University of Chinese Medicine, Harbin 150040, China; E-Mail: shengzemingraz@hotmail.com
3. Privatclinic Lassnitzhoehe, 8075 Lassnitzhoehe, Austria

† These authors contributed equally to this work.

* **Correspondence:** Gerhard Litscher; E-Mail: gerhard.litscher@medunigraz.at**Academic Editor:** Hegyi Gabriella**Special Issue:** [Modernization of Acupuncture Education and Research](#)*OBM Integrative and Complementary Medicine*
2020, volume 5, issue 1
doi:10.21926/obm.icm.2001015**Received:** February 12, 2020**Accepted:** March 16, 2020**Published:** March 20, 2020**Abstract**

Pain could be directly related to autonomous imbalance. To date, only one scientific work examining heart rate variability (HRV) and heart rate (HR) as the important parameters of autonomous nervous system (ANS) in the context of clinical routine acupuncture treatments for lumbosacral pain conditions is available in the listed databases. The present study aimed to investigate the short-term effects of HRV and HR, during and after the acupuncture needle stimulation in patients with lower back pain. Eighteen patients (mean age \pm SD: 60.2 \pm 12.0 years; 15 males and 3 females) were included in the present study. All the investigations were performed at the Privatclinic Lassnitzhoehe, Austria. The trial was conducted and integrated into routine acupuncture therapeutic interventions. Heart rate, as well as heart rate variability, was measured continuously during needle acupuncture. The



© 2020 by the author. This is an open access article distributed under the conditions of the [Creative Commons by Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium or format, provided the original work is correctly cited.

main acupuncture points were: Dachangshu (BL25), Zhibian (BL54), Huantiao (GB30), Fengshi (GB31), Yanglingquan (GB34), Xuanzhong (GB39), and Taichong (LV3). The results demonstrated that in comparison to the only existing previous study on the topics of HRV, HR, acupuncture, and lumbosacral pain, similar HR and LF/HF-HRV pattern changes were observed in the present study, while certain slightly different HRV_{total} changes were observed as well. There is evidence that acupuncture may affect the balance of the ANS in patients during lumbosacral acupuncture treatment. Further investigations in this regard are in progress.

Keywords

Acupuncture; heart rate variability (HRV); low-back pain (LBP); lumbosacral pain; rehabilitation; heart rate (HR); autonomic nervous system (ANS)

1. Introduction

Treatment of Lower Back Pain (LBP) using acupuncture mainly involves controlling or reducing pain to return to normal life activities as soon as possible. The most recent international guidelines regarding the topic recommend pharmacological management for pain relief in LBP, which includes paracetamol, non-steroidal anti-inflammatory drugs, muscle relaxants, opioid analgesics, epidural steroids, anticonvulsants, antidepressants, and corticosteroids, among others [1]. However, most of these pharmacological treatments provide limited pain relief and are accompanied by serious side effects, such as drowsiness, dizziness, addiction, allergic responses, reversible reduction in the liver function, and negative impacts on gastrointestinal functions [1]. This raises the requirement for complementary treatments for LBP. Such treatments include multidisciplinary rehabilitation based on physiotherapy, spinal manipulation, exercise therapy, massage therapy, cognitive-behavior therapy, yoga, tai-chi, and acupuncture [1].

The aim of the present study was to investigate the short-term effects of heart rate (HR) and heart rate variability (HRV) during the acupuncture treatment in patients with LBP.

2. Methods

2.1. Patients

A total of 18 patients (mean age \pm SD: 60.2 \pm 12.0 years; age range: 38–84 years; mean height \pm SD: 167.9 \pm 7.8 cm; mean weight \pm SD: 82.9 \pm 14.1 kg; mean body mass index (BMI) \pm SD: 29.4 \pm 4.9 kg/m²; 15 females and 3 males) were enrolled in the study. The enrolled patients did not have any severe neurological or orthopedic disorders. Therefore, no numerical rating scale was used. All the investigations were performed at the Privatclinic Lassnitzhoehe in Austria. The recruitment of the patients for the study was conducted by an experienced neurologist. It was the first acupuncture session for each of the enrolled patients, as none had undergone acupuncture therapy previously. All the patients provided oral informed consent for participation in the study, and the study was performed in accordance with the principles of the Declaration of Helsinki.

Ethical permission for the study was obtained from the institutional review board of the Privatclinic Lassnitzhoehe [2].

2.2 Study Procedures

The study was performed and integrated into routine acupuncture therapeutic interventions. Therefore, there was no control group for the trial. All the patients were subjected to needle acupuncture. The HR and HRV data were analyzed during one single 30-minute-long acupuncture session.

2.3 Acupuncture Points and Needling Technique

The acupuncture points used for LBP treatment in the present study for each patient are listed in Table 1. The description of the acupuncture points is provided in Table 2. The main acupuncture points are depicted in Figure 1.

Table 1 Acupuncture points for LBP used in the present study.

Patient number	Side (right R, left L)	Main acupuncture points for LBP *	Additional acupuncture points
1	R	Dachangshu (BL25);	L4 Jiaji point; 1 Ashi point
2	L	Zhibian (BL54); Huantiao (GB30);	L4 Jiaji point; L5 Jiaji point; 1 Ashi point; Ciliao (BL32); Zusanli (ST36)
3	L	Fengshi (GB31); Yanglingquan (GB34);	L4 Jiaji point; L5 Jiaji point; 1 Ashi point; Zusanli (ST36)
4	L	Xuanzhong (GB39);	L4 Jiaji point; 1 Ashi point; Zusanli (ST36)
5	R	Taichong (LV3)	L4 Jiaji point; L5 Jiaji point; 2 Ashi point; Zusanli (ST36)
6	R		L5 Jiaji point; 1 Ashi point; Zusanli (ST36)
7	L		L3 Jiaji point; L4 Jiaji point; L5 Jiaji point; 1 Ashi point; Shangliao (BL31); Zusanli (ST36); Zhongji (Ren3)
8	R		L4 Jiaji point; L5 Jiaji point; 1 Ashi point; Zusanli (ST36)
9	R		L4 Jiaji point; L5 Jiaji point; Shangliao (BL31); 1 Ashi point; Zusanli (ST36)
10	L		L4 Jiaji point; L5 jiaji point; 1 Ashi point; Zusanli (ST36)
11	L		L3 Jiaji point; L4 Jiaji point; 1 Ashi point; Zusanli (ST36)
12	R		L4 Jiaji point; L5 Jiaji point; 1 Ashi point; Shangliao (BL31); Ciliao (BL32); Zusanli (ST36)
13	L		L4 Jiaji point; 2 Ashi point; Weizhong (BL40); Zusanli (ST36)

14	L		L1 Jiaji point; L4 Jiaji point; L5 Jiaji point; 2 Ashi point; Zusanli (ST36)
15	L		L4 Jiaji point; L5 Jiaji point; 1 Ashi point; Zusanli (ST36)
16	R		L4 Jiaji point; L5 Jiaji point; 1 Ashi point; Zusanli (ST36)
17	R		L4 Jiaji point; L5 Jiaji point; 1 Ashi point; Zusanli (ST36)
18	L		L4 Jiaji point; L5 Jiaji point; 1 Ashi point; Zusanli (ST36)

*All patients were treated with these main points.

Table 2 Description of the acupuncture points for LBP used in this study (approx.: approximate; 1 cun = one thumb width) [3].

Acupuncture point	Anatomical location	Indication
Dachangshu (BL25)	1.5 cun lateral to the lower border of the spinous process of L4, approx. level with the upper border of the iliac crest	1. Abdominal distension, diarrhea, constipation 2. Lower back and leg pain 3. Sciatica 4. Enuresis, nephritis
Zhibian (BL54)	On the buttock, in the depression, 3 cun lateral (about 4 fingerbreadths) to the sacral hiatus.	1. Lumbosacral pain 2. Lower limb muscle atrophy, weakness, pain, etc. 3. Difficult urination 4. Constipation, hemorrhoids
Huantiao (GB30)	1/3 the distance from the prominence of the greater trochanter to the sacral hiatus	1. Lumbosacral pain 2. Lower limb muscle atrophy, weakness, pain, etc.
Fengshi (GB31)	On the lateral aspect of the thigh, directly below the greater trochanter, 7 cun above the popliteal crease	1. Lower limb paralysis 2. Itching all over the body 3. Sciatica, lateral femoral dermatitis, etc.
Yanglingquan (GB34)	In the depression anterior and inferior to the prominence of the head of the fibula	1. Jaundice, vomiting 2. Hypochondriac pain 3. Paralysis of lower limbs 4. Knee joint diseases, etc.
Xuanzhong (GB39)	3 cun superior to the prominence of the lateral malleolus, between the posterior border of the fibula and the tendons of peroneus longus & brevis	1. Hypochondriac pain 2. Paralysis of lower limbs, 3. Dementia, stroke, headache, dizziness, etc.

Taichong (LV3)	On the dorsum of the foot, in the hollow distal to the junction of the first and second metatarsal	<ol style="list-style-type: none"> 1. Jaundice, vomiting, hypochondriac pain 2. Paralysis of lower limbs, swelling and sore feet 3. Dementia, stroke, headache, dizziness 4. Irregular menstruation, dysmenorrhea, etc.
L1 Jiaji point	0.5 cun lateral to the lower border of the spinous process of L1 approx.	Lower back pain, lower limb pain
L3 Jiaji point	0.5 cun lateral to the lower border of the spinous process of L3 approx.	
L4 Jiaji point	0.5 cun lateral to the lower border of the spinous process of L4 approx. level with the upper border of the iliac crest	
L5 Jiaji point	0.5 cun lateral to the lower border of the spinous process of L5 approx.	
Ciliao (BL32)	In the second sacral foramen	<ol style="list-style-type: none"> 1. Nocturnal emission, orchitis 2. Irregular menstruation, dysmenorrhea, 3. Difficult urination, hernia 4. Lumbosacral pain, lower limb muscle atrophy, weakness, pain, etc.
Shangliao (BL31)	In the first sacral foramen	<ol style="list-style-type: none"> 1. Irregular menstruation and other gynecological diseases 2. Nocturnal emission, constipation, difficult urination, 3. Lumbosacral pain
Zusanli (ST36)	3 cun inferior to the hollow formed by patella & patella ligament. A fingers breadth lateral to the anterior crest of the tibia at a level just inferior to the lower border of the tibial tuberosity	<ol style="list-style-type: none"> 1. Stomach ache, vomiting, bloating, dysentery constipation 2. Lower limb paralysis 3. Palpitations, insomnia, fatigue, etc.
Zhongji (Ren3)	On the anterior midline, 3 cun below the umbilicus (2 cun superior to the pubic symphysis)	Dysmenorrhea, irregular menstruation, pelvic inflammation, cystitis, sexual dysfunction, prostatitis, urinary retention
Weizhong (BL40)	On the posterior aspect of the knee, on the crease and in a depression midway between	<ol style="list-style-type: none"> 1. Lower back pain, lower limb paralysis and other lower limb disorders 2. Abdominal pain, enuresis, difficulty

	the tendons of biceps femoris and semitendinosus	urination
1 Ashi point	Local tenderness point	Treats and relieves pain

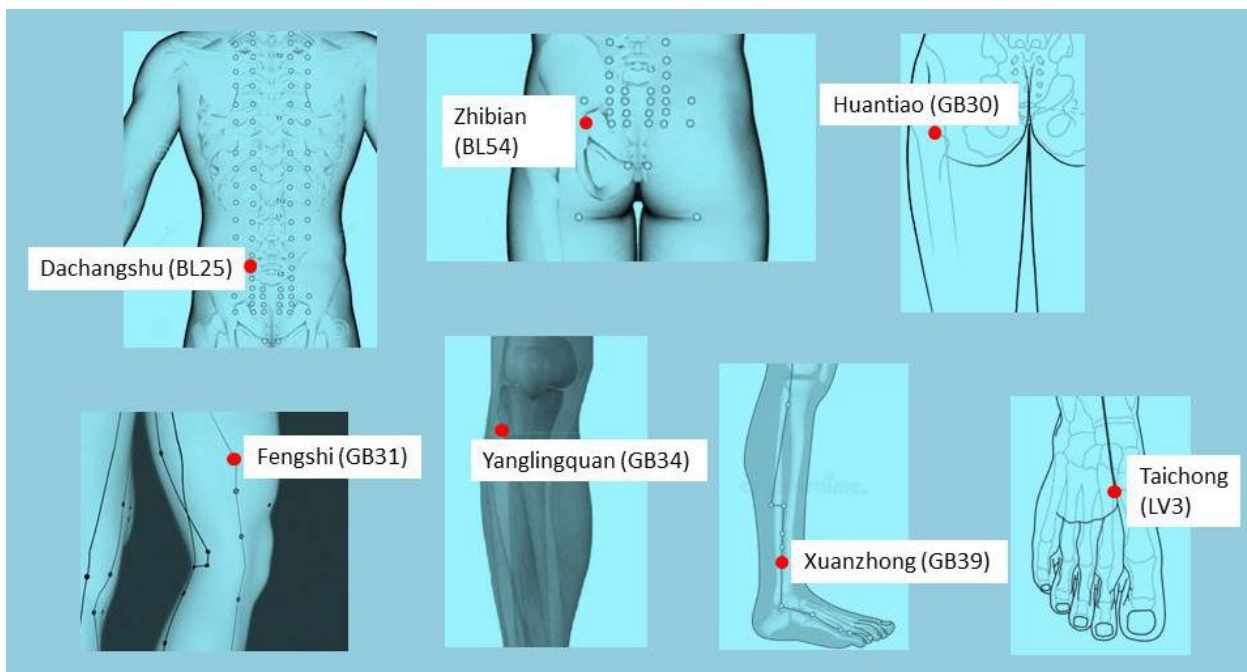


Figure 1 Main acupuncture points for low back pain (LBP).

Needling was performed in accordance with the Chinese standard procedures (with respect to depth and direction), using single-use needles (0.30 × 30 mm and/or 0.30 × 40 mm; Huan Qiu, Suzhou, China). Needle stimulation was performed clockwise as well as counter-clockwise, each for 15 s, with two rotations per second, resulting in 30 rotations per stimulation. Stimulation was performed immediately after inserting the needle, 10 min later, and immediately before removing the needles (Figure 2).

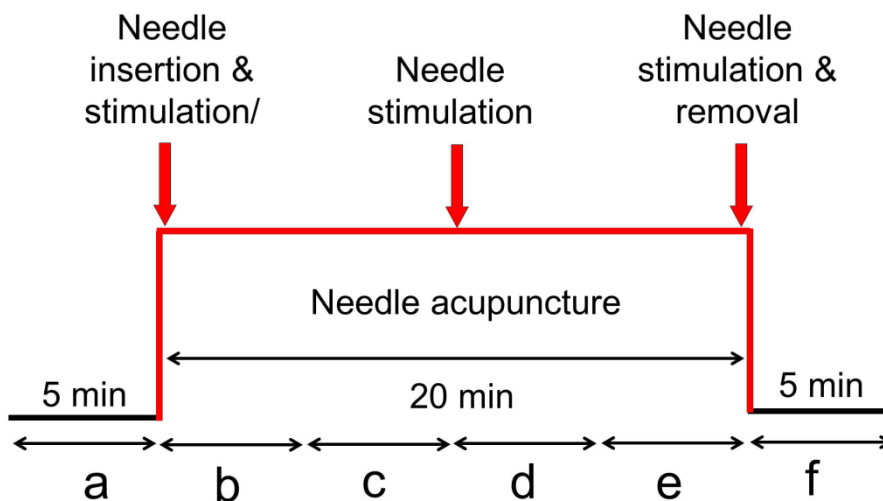


Figure 2 Measurement procedure (before acupuncture (a); during acupuncture (b–e); after acupuncture (f)).

2.4 Evaluation Parameters

HR and HRV, which have been used successfully in numerous acupuncture studies conducted previously, were the primary target parameters for the present study [4]. The parameters were measured in a quiet room after a resting period of at least 5 min. The HRV analysis was performed using Medilog® AR12 HRV system (Huntleigh Healthcare, Cardiff, UK) from the TCM research center of the Medical University in Graz. Registration was performed using three adhesive electrodes (Skintact Premier F–55; Leonhard Lang GmbH, Innsbruck, Austria) applied to the chest of each patient. Six measuring phases (a–f; Figure 2), each being 5-min long, were compared, one prior to stimulation (a), four during the acupuncture treatment (b–e), and one after the acupuncture treatment (f).

HR and HRV were measured continuously during the acupuncture treatment. The sampling rate of the HRV system was 4,096 Hz. The raw electrocardiographic data were stored on a memory card, and were subsequently read out using a card reader connected to a standard computer. HRV was presented in such a manner that the function of the autonomic nervous system was assessable [4]. Low frequency/high frequency (LF/HF) and the mean value of the heart rate (HR), recommended by the Task Force of the European Society of Cardiology and the North American Society for Stimulation and Electrophysiology, were quantified as the electrocardiographic variables [5].

2.5 Statistical Analysis

Data analysis was performed using SigmaPlot 14.0 software (Systat Software Inc., Chicago, IL). Graphic presentation of the results was achieved using box plot illustrations. Testing was performed using a one-way repeated measures analysis of variance, Kruskal-Wallis one-way analysis of variance on ranks, and Tukey's test. The significance threshold was set at $P < 0.05$.

3. Results

The mean HR prior to, during, and after the acupuncture treatment of the 18 patients are presented in Figure 3. No significant alterations were observed either among the different conditions (a–f) or prior to and after the acupuncture treatment ($P = 0.975$). HR did not appear to change significantly during the first phase (b) after the insertion of needles.

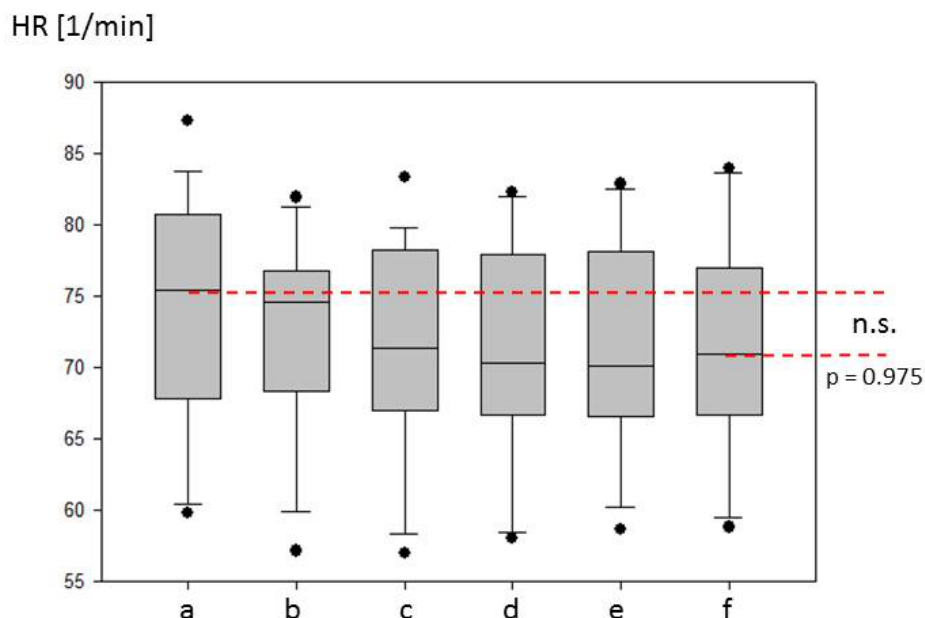


Figure 3 Mean heart rate (HR). Box plot illustration for the 18 patients with lower-back pain prior to (a), during (b–e), and after (f) the needle acupuncture treatment. No significant changes were observed. The dotted horizontal lines in the boxes depict the position of the median. The end of the box defines the 25th and 75th percentiles, and the error bars mark the 10th and 90th percentiles (n.s.: not significant).

The results for the analysis of total HRV are depicted in Figure 4. A significant decrease in total HRV was observed during and immediately after the acupuncture treatment.

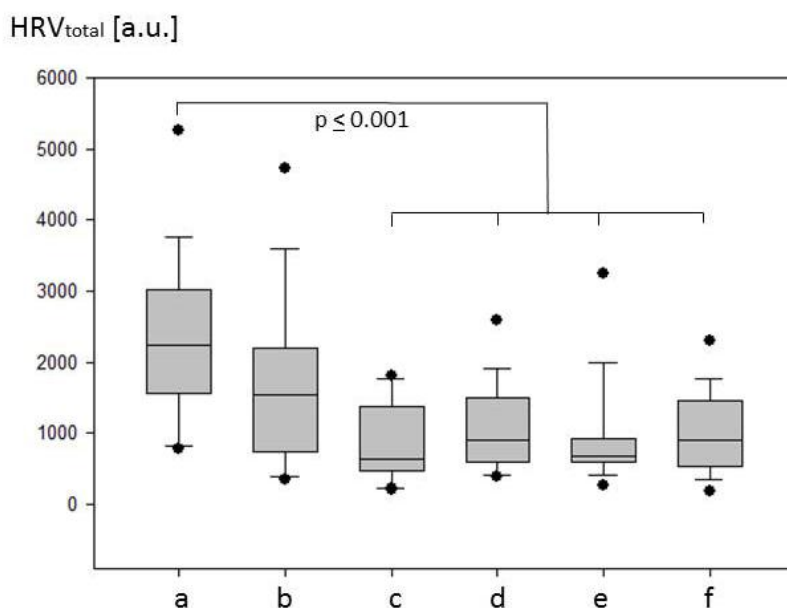


Figure 4 Total heart rate variability (HRV). Box plot illustration for 18 patients with low-back pain before (a), during (b–e), and after (f) needle acupuncture. The graphic shows significant changes during the phases c–f (a.u. = arbitrary unit). Further explanations are given in Figure 3.

Furthermore, during and after the acupuncture treatment, significant reductions in the LF/HF ratio of the HRV were observed (Figure 5).

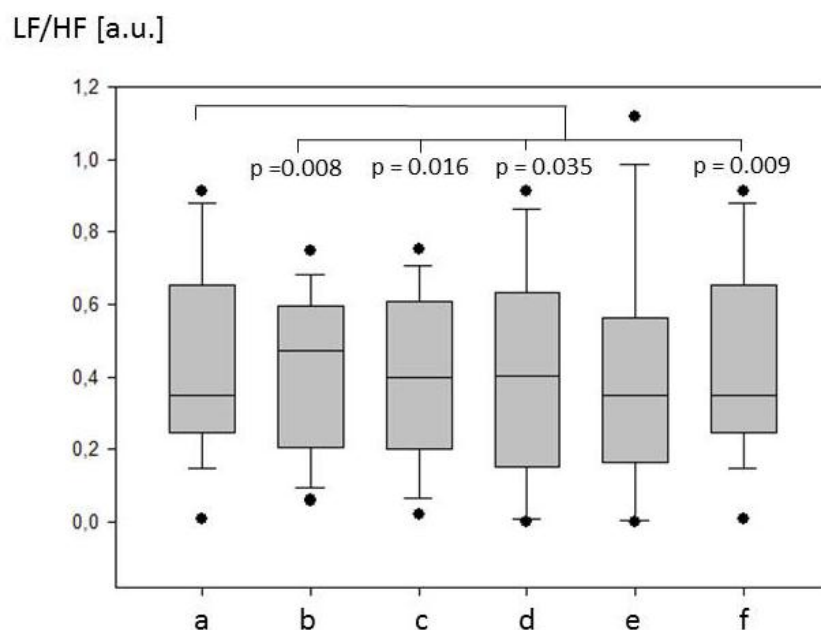


Figure 5 LF (low frequency)/HF (high frequency) ratio. Box plot illustration for the 18 patients with low-back pain before (a), during (b–e), and after (f) needle acupuncture. Further explanations are given in again Figure 3.

4. Discussion

HRV is an index representing the function of the autonomic nervous system (ANS), and serves as a reliable method for obtaining information regarding the sympathetic and parasympathetic nervous systems. Recent studies have demonstrated that changes in sympathovagal balance could be related to acupuncture treatment [4].

The present exploratory study was aimed to evaluate the effect of acupuncture treatment on the ANS reactivity in patients with lumbosacral pain. The results revealed that compared to the only existing study on the topic of HRV, acupuncture, and lumbosacral pain [2], similar HR and LF/HF-HRV pattern changes were observed in the present study as well, while certain slightly different HRV_{total} changes were also observed.

There is evidence that acupuncture is capable of affecting the balance of the ANS. Generally, acupuncture is able to improve either vagal or sympathetic tone, depending on which acupuncture points have been stimulated [4]. In the present study, the LF/HF value during and after the acupuncture treatment increased significantly compared to the initial values before the treatment. A possible reason for the statistical significance of the results of the present study, as well as the previous study [2], could be that acupuncture, as a kind of external stimulation, stimulates the human body to elicit its reflex defense reaction. However, a stress response caused by adequate needling may gradually disappear and turn into positive stimulation.

Acupuncture has been used frequently in the past for the treatment of lower back pain [1]. The underlying mechanism could be related to the activation of endogenous opioids and neuropeptides through the stimulation of specific structures in the brain. It has been reported that acupuncture could be applied as a supplementary procedure to reduce pain and thereby improve the quality of life in patients [1].

The ANS comprises two components the sympathetic nervous system which is responsible for the flight and stress reactions, and the parasympathetic nervous system, which dominates when a person relaxes. The low-frequency band LF (0.04–0.15 Hz) in HRV mainly reflects the sympathetic activity, while the high-frequency component HF (0.15–0.4 Hz) is regarded as an index of parasympathetic nerve activity. The LF/HF ratio, therefore, reflects the sympathovagal balance [1,2,4,5,6].

The patients suffering from pain could have impaired ANS function. A previous study conducted by our research group demonstrated that the LF/HF ratio was significantly increased in patients after treatment of the lumbosacral pain [2]. Although the present study did not exactly demonstrate this type of outcome, there nonetheless exists a parallel to this previous study. The results clarified that the LF/HF ratio, and not the mean HR, could be modulated through the acupuncture treatment using different acupuncture points. ANS modulation is closely related to the ANS tone (medium HR), and is, therefore, associated with an increase in the sympathetic activity and a decrease in the vagal tone, and consequently with an increase in HR and a decrease in its variability [6]. This implies that a physiological correlation exists between HRV and HR. However, in a simulation study, it was demonstrated that the changes in the ANS modulation should be independent of the changes in the mean HR [7]. This is consistent with the findings of the present study. Acupuncture is able to modulate the ANS through the activation of the sympathetic and parasympathetic nervous systems.

The present study also has certain limitations. Firstly, the sample size was relatively small, which limits the significance of the possible different effects of using different acupuncture methods (points). Since there is only one similar study reported previously [2], it was not possible to calculate the sample size on the basis of differences in the HRV modulated using needle acupuncture treatment. Secondly, registration of a control group was not possible in this preliminary trial because, as stated in the introduction section, the tests were integrated into the routine acupuncture therapeutic interventions in a rehabilitation clinic. Thirdly, it would be interesting for future studies to evaluate how the duration of the acupuncture treatment (at least 6 to 10 sessions) would affect the clinical outcomes. It is possible that more prolonged acupuncture treatment would be more beneficial for pain relief. Finally, although the acupuncture points commonly used to treat LBP are Yaoyu (GV2), Huantiao (GB30), Yanglingquan (GB34), Shenshu (BL23), Dachangshu (BL25), Yaoyangguan (GV3), and Weizhong (BL40) [8,9], a slightly modified acupuncture scheme was used in the present study. Since no control group was used, it appeared at first that it was unclear whether the changes being observed were a result of the acupuncture treatment, the act of lying down for 30 min, or the psychological factors such as hoping to achieve pain relief from the treatment or all of the above. However, in relation to previous works [2,4], the possibility of the measured effects arising only from lying down or from psychological factors could be excluded.

In 2010, Lee et al. [10] summarized the important references in the literature and stated that sham-controlled randomized controlled studies presented variable results and no clear evidence

that acupuncture exerted any specific effects on HRV. Therefore, more rigorous research is warranted. Meanwhile, extensive basic research has been conducted regarding this topic, which clearly demonstrates that acupuncture and, for example, moxibustion could exert effects on HR and HRV, respectively [6,11].

The results of the present study, which represent a low vagal tone, could be associated with qi deficiency based on the TCM theory, according to a previous study [12]. Moreover, qi deficiency is one of the significant diagnoses made by the traditional Chinese medical acupuncturists for patients with lower back pain [13]. Therefore, the change in the HRV of patients observed in the present study possibly reflects that acupuncture has a therapeutic effect on the patients with lower back pain through the regulation of the balance of qi.

Future research could include other assessment variables and the investigation of the long-term HRV effects of different acupuncture schemes on patients with lumbosacral pain.

5. Conclusion

The present study revealed that HR did not change significantly, while there were significant changes in HRV_{total} and the LF/HF ratio of HRV during a single acupuncture session in the patients with LBP. There was a significant alteration in HRV between the time points of the beginning and the completion of the acupuncture treatment. Current studies related to this topic are limited in number and have been conducted in very small groups, rendering it difficult to draw reliable conclusions. Therefore, future studies using the same standardized acupuncture scheme in all patients and involving a greater number of acupuncture sessions shall assist in elucidating certain open questions in this field of study.

Acknowledgments

The article has been written during a 6-month research stay of Mrs. Yan Yang, MA at Medical University of Graz under supervision of Prof. Gerhard Litscher which was supported by a scholarship from Eurasia-Pacific Uninet. Prof. Litscher, Priv.Do. Dr.med. Lu Wang and Dr.med. Zemin Sheng are also Visiting Professors at the Heilongjiang University of Chinese Medicine in Harbin, China. All authors would like to thank Prim. Walter Kreuzig, MD, Head of Medical Affairs at the Privatclinic Lassnitzhoehe, for his support for this study.

Author Contributions

All authors (Y.Y., G.L., Z.S., and L.W.) designed the study. Z.S. and Y.Y. performed the acupuncture and the HRV measurements in the clinic. Y.Y. and G.L. analysed the data. G.L. wrote the paper with input from all authors (Y.Y., Z.S., L.W.).

Funding

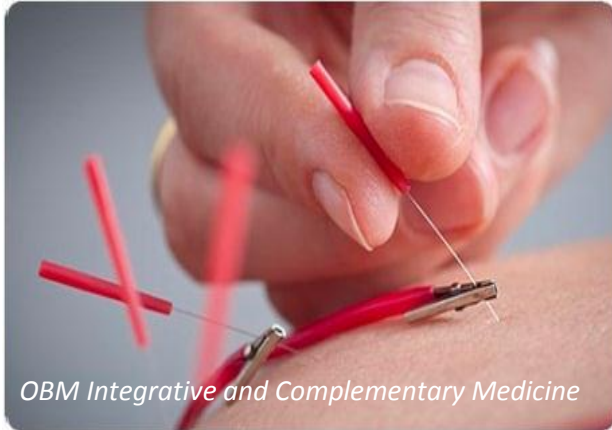
Eurasia Pacific Uninet, Austria and TCM Research Center Graz, Medical University of Graz, Austria, Europe.

Competing Interests

The authors have declared that no competing interests exist.

References

1. Lim TK, Ma Y, Berger F, Litscher G. Acupuncture and neural mechanism in the management of low back pain - An update. *Medicines (Basel)*. 2018; 5: pii: E63. doi: 10.3390/medicines5030063.
2. He W, Sheng Z, Wang L, Gaischek I, Litscher G. Modulation of autonomic nervous system during and after acupuncture treatment of lumbosacral pain in woman: A preliminary clinical observation. *Med Acupunct*. 2013; 25: 209-214.
3. Shen XY. Meridian and acupoints studies. China Traditional Chinese Medicine Press; 2008.
4. Litscher G. Heart rate variability and acupuncture. Results from transcontinental studies. Lengerich, Germany: Pabst Science Publishers; 2019. 229p.
5. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. *Eur Heart J*. 1996; 17: 354-381.
6. Tu JF, Kim M, Yang JW, Li QQ, Litscher G, Wang L, et al. Influence of acupuncture on autonomic balance in adult tinnitus patients: An exploratory study. *Curr Med Sci*. 2019; 39: 947-953.
7. Bolea J, Pueyo E, Orini M, Bailón R. Influence of heart rate in non-linear HRV indices as a sampling rate effect evaluated on supine and standing. *Front Physiol*. 2016; 15: 501. eCollection 2016.
8. Yan J. Skills with Illustrations of Chinese Acupuncture and Moxibustion. Hunan, China: Hunan Science & Technology Press; 2006.
9. Berman BM, Langevin HM, Witt CM, Dubner R. Acupuncture for chronic low back pain. *N Engl J Med*. 2010; 363: 454-461.
10. Lee S, Lee MS, Choi JY, Lee SW, Jeong SY, Ernst E. Acupuncture and heart rate variability: A systematic review. *Auton Neurosci*. 2010; 155: 5-13. doi: 10.1016/j.autneu.2010.02.003.
11. Shu Q, Wang H, Litscher D, Wu S, Chen L, Gaischek I, et al. Acupuncture and moxibustion have different effects on fatigue by regulating the autonomic nervous system: A pilot controlled clinical trial. *Sci Rep*. 2016; 6: 37846. doi: 10.1038/srep37846.
12. Olivera-Toro A, Fossion R, Li L, et al. Changes in heart rate variability in patients with spleen-qi deficiency syndrome. *J Acupunct Meridian Stud*. 2019; 12: 111-121.
13. Sherman KJ, Cherkin DC, Hogeboom CJ. The diagnosis and treatment of patients with chronic low-back pain by traditional Chinese medical acupuncturists. *J Altern Complement Med*. 2001; 7: 641-650.



Enjoy *OBM Integrative and Complementary Medicine* by:

1. [Submitting a manuscript](#)
2. [Joining in volunteer reviewer bank](#)
3. [Joining Editorial Board](#)
4. [Guest editing a special issue](#)

For more details, please visit:

<http://www.lidsen.com/journals/icm>