

A Randomized Clinical Trial Comparing the Effect of Yoga and Thai Massage among Garment Industry Population with Non-Specific Low Back Pain

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Abstract

Background: Low back pain has an enormous societal and economic impact on the working-age population, and a large number of women are affected due to sedentary work environment. Treatment is often delayed as the symptoms are initially unclear and with progressive age, healthy ageing is compromised. Hence the study investigates the effects of the Integrated Approach of Yoga Therapy (IAYT) and Thai Massage (TM) on Non-Specific Low Back Pain (NSLBP). **Method:** We randomly allocated a total of 52 women employees from an Indian Garment Industry located in South Bangalore, into the IAYT group (n = 26, age 35.46 ± 7.78), and TM group (n = 26, age 34.23 ± 6.67). For the IAYT group, a yoga therapy module for 45 minutes for 5 days a week for 12 weeks was administered and for the TM group, a set of self-stretching exercises combined with Thai self-massage using a back massage stick for the same duration was administered. The assessment was done at baseline and after 12 weeks for both groups on the clinical parameters, back disability, depression, anxiety, stress, pain intensity, and biofield energies using Electro Photonic Imaging (EPI).

Results: Statistical analysis was performed using Statistical Package for the Social Sciences, version 20.0 for Windows (SPSS Inc., Chicago, IL, USA). For within-group analysis, the Wilcoxon signed-rank test was used and for between-group analysis, Mann-Whitney U test was used. The IAYT group showed reduced back disability, and pain intensity at (75.24% and 66.92%) respectively, comparatively better than TM at (65.32% and 62.73%) respectively. The IAYT group showed a better improvement in depression, anxiety, and stress at

(75.44%, 64.48%, and 63.35%) respectively as compared to the TM group at (55.75%, 57.03%, and 52.31%) respectively with $P < 0.001$. Further, the IAYT group has shown considerable improvement in weight, waist-hip ratio, BMI, respiratory rate and pulse rate at (1.88%, 3.68%, 2.23%, 12.32%, and 4.06%) respectively as compared to TM group at (1.7%, 2.19%, 1.92%, 3.61% and, 1.67%) respectively with $P < 0.05$. In the scores of EPI, the IAYT group demonstrated significant improvement in stress and lumbar spine energy area levels at (13.96%, and 44.02%) respectively as compared to the TM group at (5.42%, and 7.16%) respectively with $P < 0.05$.

Conclusions: IAYT seems to work more effectively for nonspecific low back pain than TM for female garment employees.

Keywords: *Integrated Approach to Yoga Therapy, Low Back Pain, Thai Massage, Employees.*

Introduction

Low back pain (LBP) is defined as muscle tension and pain in the lower back region with or without sciatica (Hoy et al., 2014). It is a known leading cause of debility globally, with 619 million reporting since 2020, and has significant societal and economic impacts on the working-age population (Cheng et al., 2023). Hence, a decade of healthy ageing has been promoted by the United Nations for 2020–30, which provides a space for global health initiatives to extend their support and reduce LBP (Carregaro et al., 2020). The prevalence of NSLBP at 84% is quite common (Buttagat et al., 2020) and there is no identifiable pathological cause (Maher et al., 2017). NSLBP intensity varies with posture and can be categorized into flexion, active extension, and multidirectional affecting more than 80% of LBP patients worldwide (Dankaerts et al., 2006; Divya et al., 2021; Suzuki et al., 2016)

The International Labour Organization (ILO) estimates that musculoskeletal diseases account for 40% of all work-related injuries (Rajagopal, 2003) while the World Health Organization (WHO) reports that LBP is prevalent in 60–70% of industrialized countries, accounting for significant productivity losses (Punnett et al., 2005). One-quarter of Years to live with disability (YLDs) due to LBP attributed to static posture, jerky movements, and physically demanding tasks (Roffey et al., 2010; Schofield et al., 2008; Sunisa et al., 2020; Wai et al., 2010). Among working-age people, LBP has a high prevalence amongst women as compared to men who suffer from YLDs due to occupational ergonomics (21.4%–23.4%), and it increases with age affecting daily tasks and socializing (Rudy et al., 2007).

The garment industry is the key market entry point for developing countries like India where the ready-made garment industry supplies around 8% of exports and 7% of industrial output and is the country's sizable employer after agriculture (Awashthi, 2003). The LBP prevalence in the garment industry ranges from 8.75% to 78.89% (Bindra et al., 2017) and is likely to surge due to static sitting behaviour among women more than men (Paudyal, 2013). In sedentary workers, sustained stretching of passive lumbar structures might exacerbate LBP (Mork & Westgaard, 2009) and in clothing factories, seated employees aged 17 to 40 are highly susceptible to LBP (Anannontsak & Puapan, 1996) due to increased intradiscal pressure (Nachemson, 1981) and anteroposterior shear flexibility, stressing the posterior region and leading to disability (Donald et al., 1999; Wilder, 1993).

Weight issues and increased body mass index (BMI) in chronic low back pain (CLBP) involve physical challenges, pain symptoms, perceived disability, decreased functional task performance (Vincent et al., 2014) and compromises the lumbar endurance muscles leading to poor quality of life (QoL) (Simmonds et al., 2012). Peaking with age, LBP compromises the prospect of healthy ageing (Ferreira et al., 2023) and the impacts not only in the physical domain such as pain intensity, and functional disability (Klemenc-Ketis, 2011) but also in psychological variables such as distress, depression, and somatization as well as in its progression compared to mechanical factors (Hong et al., 2014; Shahin et al., 2022).

IAYT involves components like Asanas-postures, Pranayama-breathing techniques, and Dhyana-meditation (Nagendra & Nagarathna, 2016). It uses the mind-body collaboration concept (Ng et al., 2023) and brings awareness and bidirectional communication between the mental, nervous, skeletal, and muscular systems (Hill, 2013). Yoga ranks 5th among Complementary and Alternative Medicine (CAM) treatments (Erik et al., 2013) and its bio-psychosocial approach is considered the gold standard for chronic pain treatment for CLBP (Gatchel et al., 2007) as endorsed by the American Pain Society and the American College of (Chou & Huffman, 2007).

As a mind-body therapy, Yoga addresses depression (Nilakanthan et al., 2016; Sharma et al., 2005) stress, and anxiety (Granath et al., 2006; Sherman et al., 2011; Smith et al., 2007; Tilbrook et al., 2011) improves balance, spinal flexion, and extension, and decreases disability, and pain intensity in CLBP condition (Tekur et al., 2008). The perception of recovery and pain intensity is better with yoga than with conventional therapeutic exercises (Li et al., 2019). In conditions like sciatica and NSLBP that result in bulging or extruding discs, yoga therapy strengthens core muscles, improves posture (Wang et al., 2018) and is considered to be an effective adjunct therapy for CLBP (Sherman et al., 2013).

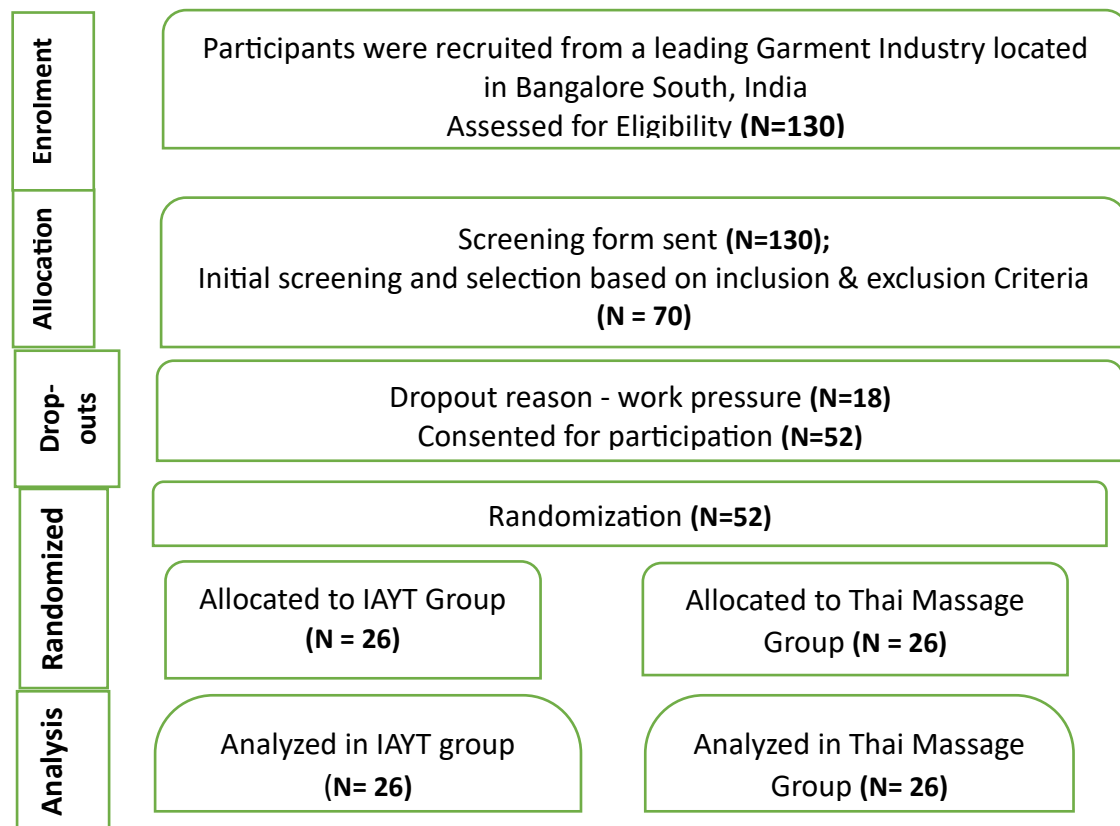
Thai Massage (TM) involves soft stretching and applies sustained pressure on the 'Sen Sib' lines. It combines acupressure, reflexology, assisted yoga postures, and joint mobilization (Koch & Hänsel, 2019). Physically, TM increases muscle flexibility (Göktuğ & İnci, 2023) improves blood circulation (Viravud et al., 2017) changes brain's electrical activity (Buttagat et al., 2011) and is associated with a significant increase in parasympathetic activities that promotes physical and mental relaxation (Buttagat et al., 2011). TM increases bone formation by increasing procollagen 1 amino-terminal propeptide levels in the serum (Saetung & Chailurkit, 2013) and significantly decreases electromyographic activity to reduce pain (Buttagat et al., 2016). Hands-on treatment, or touch therapy, is more common in massage therapies (Ke-Lin et al., 2020) and TM uses a self-massage stick that applies ischemic pressure to trigger points and has shown significant improvement in pain management and flexibility (Buttagat et al., 2020; Wamontree et al., 2015).

Back pain causes functional disability and mental and emotional symptoms wherein, yoga and massage techniques are widely used. Despite the fact that there are many independent scientific studies on yoga and TM, there is no comparative study comparing IAYT practices with Thai Self-Massage techniques. Further, there is no study comparing the effectiveness of IAYT and TM in the working population of Garment Industry. Therefore, the present study compares the effects of IAYT practices and TM self-back massage on pain, back disability, depression, anxiety, stress scales, and energy measurements using electrophonic imaging on the NSLBP.

Method:

Design and Setting: A prospective, parallel-group, open-label randomized trial was conducted at a leading Garment Industry located in Bangalore, South India. This study follows CONSORT 2017 Statement for Randomized Trials of Nonpharmacologic Treatments as well as its extension (Boutron et al., 2017).

Participants: This study included 25- to 50-year-old NSLBP female participants who were recruited from the Garment Industry. The trial was conducted for a period of 3-months from April 2023 to June 2023. The participant flow chart is presented in (*Figure 1*). The baseline characteristics of the study sample were equally balanced between the two groups as presented in (*Table 1*).

Figure: 1 Consolidated Standards of Reporting Trials (CONSORT) FLOW CHART**Table 1: Baseline Characteristics of Subjects**

		IAYT	TTM
	Variables	Number (%)	Number (%)
Age	Mean $\pm$ SD	35.46 $\pm$ 7.78	34.23 $\pm$ 6.67
Marital status	Married	17 (65.38)	18(69.23)
	Single	9 (34.61)	8(30.76)
	Children	13 (50)	17(65.38)
Education	10th	2 (7.69)	9(34.61)
	12 th	17 (65.38)	14(53.85)
	Graduation	7 (26.92)	3(11.54)
Location of Pain	Lower	25 (96.15)	21(80.77)
	Lower and Middle	1 (3.84)	5(19.23)
Comorbidity	BP	1 (3.85)	6 (23.07)
Diet	Vegetarian	9(34.62)	2(7.69)
	Non-vegetarian	17(65.38)	24(92.30)

Ethical consideration: Informed Consent form was duly signed by all the participants. The study was approved by the Institutional Ethics Committee of SVYASA (RES/IEC-SVYASA/273/2022) and is prospectively registered with Clinical Trials Registry – India (CTRI/2023/03/050793).

Inclusion criteria: Sitting Working professionals were considered (Pope et al., 2002) and the selection of the participants was based on the definition of NSLBP with no indication of functional or structural deviations (Mackawan et al., 2007). Recruitment was based on the Orthopaedic consultation to know whether it was specific or non-specific, with the duration of pain < 6 weeks, and were not consuming any pain medication.

Exclusion criteria: Back pain resulting from gynaecological issues, menstruation, pregnancy, COVID-19 vaccination not taken; normal body temperature on the day of investigation; back surgery, spinal fractures, joint instability, inflammatory joint disease (Rheumatoid arthritis), muscle disease, malignancy, neurologic deficits, multiple sclerosis, and infectious diseases were excluded.

Sample size calculation: The sample size from a previous intervention study that compared the effect of Yoga on a visual analogue scale in CLBP was calculated (Tekur et al., 2008). The total sample size obtained was 32 by using the 'G power' software ($\alpha = 0.05$, power = 0.96, and effect size = 1.26). Considering the dropout rate of 20%, a total of 52 samples was calculated for the current trial.

Procedure:

Randomization and Intervention: All subjects were randomized into the IAYT group (n = 26) and TM group (n = 26) by using the simple randomization technique of flipping a coin. A pre-tested integrated yoga therapy module (IYTM) designed and validated for its feasibility among LBP patients (Patil et al., 2015) was used in the current trial for the IAYT group, and the TM group used self-back massage stick along with self-stretches (Buttagat et al., 2020) for NSLBP as presented in (Table 2).

Table 2: List of IAYT and Thai self-massage practices		
Duration – 45 Mins	Integrated yoga therapy module (N. Patil et al., 2015)	Thai Self-Massage (Buttagat et al., 2020)
30 Mins	Loosening Stretches: Sitting: Neck Rotation, Shoulder movements, twisting, Dorsal Stretch Supine: Straight Leg Raising, Pavanamuktasana stretch (Both alternate and both leg), Folded leg Lumbar stretch Breathing: Shashankasana=breathing, Tiger Breathing Asanas: Setubandhasana, Bhujangasana, Shalabhasana	Massage points along the two lines of paraspinal muscles should be pressed for 5 seconds each. Five seconds of pressure will be applied, then sustained Exercises: single-knee-to-chest, double-knee-to-chest, lower trunk rotation, and prone extension in three sets of ten repetitions
15 Mins	Relaxation: Deep Relaxation Technique (DRT) - 15 mins	Relaxation: Supine Rest (15 mins)

Assessments:

For the Primary outcome variables: clinical parameters were assessed for weight, respiratory rate (RR), pulse rate (PR), waist-hip ratio (WHR), body mass index (BMI), and Blood pressure (BP). The subjective pain intensity was assessed using a visual analogue scale (VAS) of 10 cm (Gallagher et al., 2002; Wilkie et al., 1990). Back disability assessment was done using the Oswestry Low Back Pain Disability Questionnaire (OLBPD) (Fairbank & Pynscent, 2000). For assessing depressive disorders, the Depression Anxiety Stress Scale (DASS-21) a 21-item tool was used (Lovibond & Lovibond, 1995).

For the secondary outcome variables: The stress levels, lumbar spine integral energy area, and its balance were assessed by means of electrophotonic imaging (EPI) that were captured to identify the functional psych emotional, and physiological state of a person using their fingertips.

Data Collection and Statistical Analysis: Data was collected at baseline and after 12 weeks of intervention. Descriptive-analytic methods were employed to analyze the gathered data. The data analysis was performed using SPSS Inc., Chicago, IL, USA version 20.0. The mean and standard deviation, or 95% confidence interval, were calculated for each variable. The data was analyzed for normality with the Shapiro-Wilk test. The Wilcoxon Signed rank test was used to compare the outcome variables before and after the treatment period within each respective group. Group comparisons were tested with the Mann-Whitney U test. For statistical difference, $P < 0.05$ was considered.

Results

Primary outcome variables: The back disability result of the IAYT group was at 75.24% and for TM at 65.32% which indicates a greater improvement in back functional disability in the IAYT group as compared to the TM group with $P < 0.001$. The measure of VAS for pain intensity for IAYT score was at 66.92% indicating better improvement than the TM group at 62.73% with $P < 0.001$. In the Depression, anxiety, and stress scales, the IAYT group was 75.44%; 64.48%; and 63.35% and the TM group was 55.75%; 57.03%, and 52.31% respectively indicating significance with $P < 0.00$ in the IAYT group as compared to the TM group. The clinical parameters in the weight domain for IAYT was 1.88% while TM was 1.7%. The waist-hip ratio in IAYT was 3.68% while the TM was 2.19%. The BMI change in IAYT was 2.23% and TM was 1.92%. The respiratory rate in IAYT was 12.32% and TM was 3.61%. The pulse rate in IAYT was 4.06% and TM was 1.67%. The systolic BP in IAYT was 0.19% and TM was 0.84%. The Diastolic BP, in IAYT was 1.48% and TM was 0.38%. As per these results, IAYT has shown considerable improvements in weight, WHR, BMI, RR, and PR, with $P < 0.001$ except BP.

Primary outcome variables

In the electrophotonic imaging, the stress domain in IAYT was 13.96% and TM was 5.42% and in the Lumbar spine integral energy area, the IAYT was 44.02% and TM was 7.16%. The energy balance of the Lumbar spine in IAYT was 1.08% and TM was 10.68%. As per these results, The IAYT group has considerably improved in stress ($P = 0.002$) and Lumbar spine Integral energy area level ($P = 0.035$) when compared to the TM.

Table 3: Pre-Post results of both the IAYT and TM

Parameters		IAYT Group				TM Group				Betw een	ANC OVA
		Pre Mean	Post Mean	%	P	Pre Mean	Post Mean	%	P	P	P
OLBPD		15.23 ± 4.78	3.77 ± 3.65	75.24	<0.001**	14.19 ± 2.87	4.92±2 .69	65.32	<0.001**	.117	.011*
PAIN		14.42± 4.46	4.77±2. 78	66.92	<0.001**	11.35± 4.24	4.23± 2.39	62.73	<0.001**	.501	.063

DASS-21	Depression	5.62±3.64	1.38±1.27	75.44	<0.001**	6.08 ± 2.56	2.69 ± 2.79	55.75	<0.001**	0.11	0.014*
	Anxiety	7.04±4.31	2.50±2.12	64.48	<0.001**	6.54 ± 2.94	2.81 ± 2.43	57.03	<0.001**	0.341	0.166
	Stress	7.04 ± 3.67	2.58±1.53	63.35	<0.001**	6.69 ± 3.54	3.19 ± 2.79	52.31	<0.001**	0.001*	0.086
		1.69 ± 1.38	.42±.70	75.14	<0.001**	1.27±.96	.23±.51	81.88	<0.001**	0.304	0.063
Clinical parameter	Weight	63.23±11.44	62.04±11.00	1.88	<0.001**	63.46±10.55	62.38 ± 9.92	1.7	<0.001**	0.869	.866
	Waist Hip ratio	36.38 ± 4.842	35.04 ± 4.386	3.68	<0.001**	38.73±5.821	37.88±5.148	2.19	.001*	.037	.000
	BMI	25.96±3.76	25.38 ± 3.46	2.23	<0.001**	27.04 ± 3.61	26.52±3.34	1.92	0.003*	0.259	.632
	Respiratory rate(RR)	17.85 ± 1.46	15.65 ± 1.26	12.32	<0.001**	18.00±1.49	17.35 ± 2.67	3.61	0.128	0.2	.011
	Pulse rate (PR)	78.46±4.58	75.27±3.24	4.06	<0.001**	77.62 ± 7.14	78.92 ± 8.33	1.67	0.398	0.22	.008
Blood Pressure (BP)	Systolic (SBP)	116.62 ± 6.22	116.85 ± 5.51	0.19	0.723	123.50±15.493	124.54 ± 18.94	0.84	0.961	.926	.286
	Diastolic (DBP)	77.58±6.34	78.73 ± 4.00	1.48	0.145	79.69±7.364	79.38 ± 10.75	0.38	0.337	0.275	.693
Bio-well	Stress	3.58 ± .50	3.08 ± .56	13.96	0.002*	3.50 ± .583	3.31 ± .68	5.42	0.197	0.206	0.027*
	Integral Energy Area (Lumbar spine)	3.18 ± .94	4.58 ± 1.10	44.02	0**	3.77 ± 1.306	4.04 ± .87	7.16	0.302	0.5	0.035*
	Balance (Lumbar spine)	84.73 ± 11.72	85.65 ± 14.87	1.08	0.839	78.88 ± 21.189	87.31 ± 9.16	10.68	0.144	0.748	0.574

Significance levels: (** $P<0.001$, * $P<0.05$).

Discussions:

The current study verified the effect of 12 weeks of IAYT as compared to 12 weeks of TM on NSLBP patients and the results show significant differences in both primary and secondary outcome variables of both groups.

For back disability, the IAYT group showed greater improvement at (75.24%) than TM at (65.32%) possibly as yoga postures target functional disabilities in the back through neurohormonal mechanisms that suppress sympathetic activity (Sengupta, 2012). Yoga aids in sustaining joint integrity by maintaining fluid pressure on the cartilage (van Valburg et al., 1998) and promotes healing by altering pro-inflammatory cytokine levels (Vijayaraghava et al., 2015).

The TM group also resulted in significant improvement, which is in agreement with a previous study (Buttagat et al., 2020), by stimulating the mechanoreceptors, that relieve spasmodic muscles, improve blood circulation, reduce disabilities, and relax the muscles (Juntakarn et al., 2017). According to TM, reducing muscle tension and increasing circulation are key mechanisms for treating chronic NSLBP (Juntakarn et al., 2017).

The result of pain intensity for the IAYT group at (66.92%) was better than the TM group at (62.73%), possibly due to yoga's mindful practices and regulated breathing mechanisms that contribute to postural alignment and reduced paravertebral spasms (Goode. AP et al., 2016; Nambi et al., 2014). Integrative yoga practice improves physical energy, reduces pain through the release of brain-derived neurotrophic factor, enhances functional restoration, spinal ability, and pain reduction (Long et al., 2001; Ülger & Yağlı, 2011). The result of pain intensity for the TM group improved marginally similar to a previous study wherein deep tissue tender point massage and lumbar traction improved back flexibility (Zheng et al., 2012) and substance P levels (Chatchawan et al., 2005).

The IAYT group has shown a considerable reduction in weight, waist-hip ratio, and BMI as compared to the TM group. As weight gain contributes to spinal loading, weight loss is the primary objective for obesity and for inducing functional abilities in LBP (Dario et al., 2015; Gou & Zheng, 2023). Body movement therapies like yoga influence the endocrine system to improve metabolism (Wasser et al., 2017), and reduce BMI, waist-hip ratio, body fat, and pain (Ibrahimi-Kaçuri et al., 2015). Furthermore, LBP is influenced by the nature of the job, physical workload, and psychosocial factors (Ibrahimi-Kaçuri et al., 2015).

In this study, Systolic BP improved marginally agreeing with a previous study, where the yoga mechanism promoted positive cardiac vagal function, neuroendocrine, metabolic, and inflammatory responses with decreased PR, RR, SBP, and DBP by reducing hypothalamic pituitary adrenal axis activation (Murugesan & Govindarajulu, 2000). Yoga breathing helps by reducing dead space ventilation, decreasing sympathetic tone, and altering fascial tensions, while its postural alignments help change the ventilation-to-perfusion ratio in the lungs. The results in RR and PR of this study are in agreement with this mechanism, and both IAYT and TM groups have shown significant improvement in their pre-post values (Srivastava et al., 2019).

Our study corresponds with a previous study indicating that yoga may be useful as an adjunctive treatment for managing depression and anxiety to improve QoL (Khalsa et al., 2018). Mechanical LBP is clearly influenced by depression which is a socially disabling disorder with a global estimated prevalence of 6%–20%, affecting 20% of women and 12% of men during their lifetime. (Guruprasad et al., 2015). Most depressive disorders have co-morbid anxiety, with low mood and anxiety symptoms that correlate with LBP and have a negative correlation with QoL (Mok & Lee, 2008). Yoga may act as an integrated therapeutic tool and a feasible intervention to help reduce oxidative stress, anxiety, and depression (Nagendra & Nagarathna, 2016). Its regulated breathing technique assists in changing pain perception as compared to massage therapy or physiotherapy (Tekur et al., 2012).

Stress gets de-stressed with the mechanism of slow yoga breathing, which decreases the excitatory pathways, overrides sympathetic activity, evokes parasympathetic responses, and regulates the respiratory and cardiovascular systems (Neha et al., 2020). This positive response to stress is better observed in the IAYT group as compared to the TM group on the DASS scale as well as the EPI measurement levels. In this study, high-voltage electrophotography is used to calculate finger corona discharge patterns affecting the biofield. The EPI parameters indicate significant bioenergetic changes for a given intervention whereby stress levels were reduced, and energy levels improved in the lumbar spine, which is in agreement with a study on stress reduction assessed by EPI for Osteopathy (Korotkov et al., 2012)

Strengths and Limitations of the study:

This is the first study that compares the effects of IAYT and TM for NSLBP on female garment workers for a duration of 12 weeks on the clinical parameters, pain intensity, back disability, depression, anxiety scores, EPI measurements on stress, and lumbar spine integral area. The potential limitation of this study is the small number of participants included and thus future studies should consider larger sample sizes to enhance the statistical power. Further, the study lacks follow-up with participants and recommends follow-up evaluations for future studies.

Conclusions: Though both of these interventions have been effective in addressing NSLBP, when compared across a greater number of parameters, the IAYT group has an upper hand in addressing NSLBP more effectively than the TM group. The authors suggest that yoga can be incorporated as an effective adjunct therapy for treating LBP along with standard of care.

References

- [1] Anannontsak, A., & Puapan, P. (1996). Effects of working postures on low back pain. . *Journal of Human Ergology*, 25(1), 65–72.
- [2] Awashthi, M., S. (2003). Global competitiveness hinges on product quality. *The Textile Magazine*, 44, 42–43.
- [3] Bindra, S., Sinha, & Benjamin. (2017). Prevalence and Risk factors of low back pain in Garment Industry workers of North Indiarkers. *International Journal of Current Research*, 9(2), 46837–46845.
- [4] Boutron, I., Altman, D. G., Moher, D., Schulz, K. F., Ravaud, P., & CONSORT NPT Group. (2017). CONSORT Statement for Randomized Trials of Nonpharmacologic Treatments: A 2017 Update and a CONSORT Extension for Nonpharmacologic Trial Abstracts. *Ann Intern Med*, 167(1), 40–47.
- [5] Buttagat, V., Eungpinichpong, W., Chatchawan, U., & Kharmwan, S. (2011). The immediate effects of traditional Thai massage on heart rate variability and stress-related parameters in patients with back pain associated with myofascial trigger points. *Journal of Bodywork and Movement Therapies*, 15(1), 15–23.
- [6] Buttagat, V., Narktro, T., Onsrira, K., & Pobsamai, C. (2016). Short-term effects of traditional Thai massage on electromyogram, muscle tension and pain among patients with upper back pain associated with myofascial trigger points. *Complementary Therapies in Medicine*, 28, 8–12.
- [7] Buttagat, V., Techakhot, P., Wiriya, W., Mueller, M., & Areeudomwong, P. (2020). Effectiveness of traditional Thai self-massage combined with stretching exercises for the treatment of patients with chronic non-specific low back pain: A single-blinded randomized controlled trial. *Journal of Bodywork and Movement Therapies*, 24(1), 19–24.
- [8] Carregaro, R. L., Tottoli, C. R., Rodrigues, D. da S., Bosmans, J. E., Silva, E. N. da, & Tulder, M. van. (2020). Low back pain should be considered a health and research priority in Brazil: lost productivity and healthcare costs between 2012 to 2016. *Plos One*, 15(4), e0230902.
- [9] Chatchawan, U., Thinkhamrop, B., Kharmwan, S., Knowles, J., & Eungpinichpong, W. (2005). Effectiveness of traditional Thai massage versus Swedish massage among patients with back pain associated with myofascial trigger points. *Journal of Bodywork and Movement Therapies*, 9(4), 298–309.
- [10] Cheng, Y. M., Yu, Y. M., Wang, Y. M., Fan, A. M., Yang, H. M., Wang, H. M., & Tang, L. M. (2023). Effects of lumbar-pelvic training combined with electroacupuncture on chronic nonspecific low back pain. *Medicine*, 102(29), e34407.
- [11] Chou, R., & Huffman, L. H. (2007). Nonpharmacologic therapies for acute and chronic low back pain: a review of the evidence for an American Pain Society/American College of Physicians clinical practice guideline. *Ann Intern Med.*, 147(7), 492–504.
- [12] Dankaerts, W., O'sullivan, P., Straker, L. M., Burnett, A. F., & Skouen, J. S. (2006). The inter-examiner reliability of a classification method for non-specific chronic low back pain patients with motor control impairment. *Manual Therapy*, 11(1), 28–39.
- [13] Dario, A. B., Ferreira, M. L., Refshauge, K. M., Lima, T. S., & Ordoñana, J. R. (2015). The relationship between obesity, low back pain, and lumbar disc degeneration when genetics and the environment are considered: a systematic review of twin studies. *The Spine Journal*, 15(5), 1106–1117.

- [14] Divya, Parveen, A., Nuhmani, S., Ejaz Hussain, M., & Hussain Khan, M. (2021). Effect of lumbar stabilization exercises and thoracic mobilization with strengthening exercises on pain level, thoracic kyphosis, and functional disability in chronic low back pain. *Journal of Complementary and Integrative Medicine*, 18(2), 419–424. <https://doi.org/10.1515/jcim-2019-0327>
- [15] Donald, D., Harrison, D., Arthur, C., Croft, D., Sanghak, O., & Harrison. (1999). Sitting biomechanics part 1: review of the literature. *Journal of Manipulative Physical Therapy*, 22(9), 594–609.
- [16] Erik, J. G., Marisa, S., & Douglas, C. (2013). Yoga as a treatment for low back pain: A review of the literature. VA San Diego Healthcare System, University of California San Diego, SDSU/UCSD Joint Doctoral Program in Clinical Psychology, USA, 332–352.
- [17] Fairbank, J., & Pynscent, P. (2000). The Oswestry Disability Index. *Spine*, 25(1), 2490–2952.
- [18] Ferreira, M. L., Luca, K. de, Haile, L. M., Steinmetz, J. D., Culbreth, G. T., Cross, M., Kopec, J. A., Ferreira, P. H., Blyth, F. M., & Buchbinder, R. (2023). Global, regional, and national burden of low back pain, 1990–2020, its attributable risk factors, and projections to 2050: a systematic analysis of the Global Burden of Disease Study 2021. *The Lancet Rheumatology*, 5(6), e316–e329.
- [19] Gallagher, E., Bijur, P., Latimer, C., & Silver. (2002). Reliability and validity of a visual analogue scale for acute abdominal pain. *Am J. Emerg. Med*, 287–290.
- [20] Gatchel, R., Peng, Y., Peters, M., Fuchs, P., & Turk, D. (2007). The biopsychosocial approach to chronic pain: Scientific advances and future directions. *Psychol Bull*, 133, 581–624.
- [21] Göktuğ, E., & İnci, Y. (2023). Comparison of the effects of connective tissue massage and classical massage on chronic mechanical low back pain. *Medicine (Baltimore)*, 102(15), e33516.
- [22] Goode, AP, Coeytaux, R. R., McDuffie, J., Duan-Porter, W., Sharma, P., & Mennella, H. (2016). An evidence map of yoga for low back pain. *Complement. Ther. Med*, 25, 170–177.
- [23] Gou, L., & Zheng, Q. (2023). How to reduce the risk of cervicgia and low back pain in obese individuals: A mendelian randomization study. *Medicine (Baltimore)*, 102(18), e33710.
- [24] Granath, J., Ingvarsson, S., Thiele, U. von, & Lundberg, U. (2006). Stress management: a randomized study of cognitive behavioural therapy and yoga. *Cognitive Behavior Therapy*, 35(1), 3–10.
- [25] Guruprasad, S., Ramakrishnan, K. S., & Shah, P. (2015). Prevalence of depression, anxiety and stress in patients with mechanical low back pain. *International Journal of Therapies and Rehabilitation Research*, 4(4), 67–72.
- [26] Hill, C. (2013). Is yoga an effective treatment in the management of patients with chronic low back pain compared with other care modalities - A systematic review. In *Journal of Complementary and Integrative Medicine* (Vol. 10, Issue 1). <https://doi.org/10.1515/jcim-2012-0007>
- [27] Hong, J. H., Kim, H. D., Shin, H. H., & Huh, B. (2014). Assessment of depression, anxiety, sleep disturbance, and quality of life in patients with chronic low back pain in Korea. *Korean J Anesthesiol*, 66(6), 444–450.
- [28] Hoy, D., March, L., Brooks, P., Blyth, F., Woolf, A., Bain, C., Williams, G., Smith, E., Vos, T., Barendregt, J., Murray, C., Burstein, R., & Buchbinder, R. (2014). The global burden of low back pain: estimates from the Global Burden of Disease 2010 study. *Ann Rheum Dis*, 73(6), 968–974.
- [29] Ibrahimi-Kaçuri, D., Murtezani, A., Rrecaj, S., Martinaj, M., & Haxhiu, B. (2015). Low Back Pain and Obesity. *Med Arch*, 69(2), 114–116.
- [30] Juntakarn, C., Prasarithra, T., & Petrakard, P. (2017). The Effectiveness of Thai Massage and Joint Mobilization. *Int J Ther Massage Bodywork*, 10(2), 3–8.
- [31] Ke-Lin, Z., Shuo, D., Qian, S., Kang, W., Pei-Dong, W., Xiao, B., Ming-Heng, C., Sheng, G., & Yang, L. (2020). Efficacy of massage therapy for postprandial distress syndrome: A protocol for systematic review and meta-analysis. *Medicine (Baltimore)*, 99(48), e23473.
- [32] Khalsa, S., Cohen, L., McCall, T., & Telles, S. (2018). The principles and practice of yoga in health care. *Int J Yoga*, 11, 86–87.
- [33] Klemenc-Ketis, Z. (2011). Predictors of health-related quality of life and disability in patients with chronic non-specific Low back pain. *Slovenian Medical Journal*, 80(5), 379–385.
- [34] Koch, C., & Hänsel, F. (2019). Non-specific Low Back Pain and Postural Control During Quiet Standing—A Systematic Review. *Front. Psychol.*, 10(586), 9.

-
- [35] Korotkov, K., Shelkov, O., Shevtsov, A., Mohov, D., Paoletti, S., Mirosnichenko, D., Labkovskaya, E., & Robertson, L. (2012). Osteopathy Assessed with GDV Electrophotonic Imaging: Effects of Osteopathy Treatment. *The Journal of Alternative and Complementary Medicine*, 18(3), 251–257.
 - [36] Li, Y., Li, S., Jiang, J., & Yuan, S. (2019). Effects of Yoga on patients with chronic non-specific neck pain: A PRISMA systematic review and meta-analysis. *Medicine (Baltimore)*, 98(8), e14649.
 - [37] Long, L., Huntley, A., & Ernst, E. (2001). Which complementary and alternative therapies benefit which conditions? A survey of the opinions of 223 professional organizations. *Complement. Ther. Med*, 9(3), 178–185.
 - [38] Lovibond, S. H., & Lovibond, P. F. (1995). *Manual for the Depression Anxiety & Stress Scales* (2nd ed.). Psychology Foundation.
 - [39] Mackawan, S., Eungpinichpong, W., Pantumethakul, R., Chatchawan, U., Hunsawong, T., & Arayawichanon, P. (2007). Effects of traditional Thai massage versus joint mobilization on substance P and pain perception in patients with non-specific low back pain. *Journal of Bodywork and Movement Therapies*, 11(1), 9–16.
 - [40] Maher, C., Underwood, M., & Buchbinder, R. (2017). NonSpecific low back pain. *The Lancet*, 389(10070), 736–747.
 - [41] Mok, L., & Lee, I. (2008). Anxiety, depression and pain intensity in patients with low back pain who are admitted to acute care hospitals. *J Clin Nurs*, 17(11), 1471–1480.
 - [42] Mork, P., & Westgaard, R. (2009). Back posture and low back muscle activity in female computer workers. *Clin Biomech (Bristol, Avon)*, 24(2), 169–175.
 - [43] Murugesan, R., & Govindarajulu. (2000). Effect of selected yogic practices on the management of hypertension. *Indian Journal of Physiology and Pharmacology*, 44(2), 207–210.
 - [44] Nachemson, A. L. (1981). Disc pressure measurements. *Spine*, 6(1), 93–97.
 - [45] Nagendra, H., & Nagarathna, R. (2016). *Yoga for Back Pain*. Vivekananda Kendra Prakashana. Reprint.
 - [46] Nambi, G. S., Inbasekaran, D., Khuman, R., Devi, S., Shanmugananth, & Jagannathan, K. (2014). Changes in pain intensity and health related quality of life with Iyengar yoga in nonspecific chronic low back pain: A randomized controlled study. *Int J Yoga*, 7(1), 48–53.
 - [47] Neha, H. P., Toral, G., & Trivedi, R. S. (2020). Effect of yoga on pulse rate and blood pressure. *Indian Journal of Clinical Anatomy and Physiology*, 7(1), 12–15.
 - [48] Ng, J. Y., Anagal, M., & Bhowmik, T. (2023). Low back pain patients' perceived effectiveness of utilizing complementary and alternative medicine: A systematic review of qualitative studies. In *Journal of Complementary and Integrative Medicine* (Vol. 20, Issue 1, pp. 47–80). De Gruyter Open Ltd. <https://doi.org/10.1515/jcim-2021-0071>
 - [49] Nilakanthan, S., Metri, K., Raghuram, N., & Hongasandra, N. (2016). Effect of 6 months intense Yoga practice on lipid profile, thyroxine medication and serum TSH level in women suffering from hypothyroidism: A pilot study. *Journal of Complementary and Integrative Medicine*, 13(2), 189–193. <https://doi.org/10.1515/jcim-2014-0079>
 - [50] Patil, N., Nagarathna, R., Tekur, P., Patil, D. N., Nagendra, H. R., & Subramanya, P. (2015). Designing, validation, and feasibility of integrated yoga therapy module for chronic low back pain. *Int J Yoga*, 8(2), 103–108.
 - [51] Paudyal, P. (2013). Low back pain among textile workers: a cross-sectional study. *Occupational Medicine*, 63(2), 129–134.
 - [52] Pope, M. H., Goh, K., & Magnusson, M. (2002). Spine Ergonomics. *Annu Rev Biomed Eng.*, 4, 49–68.
 - [53] Punnett, L., Prüss-Ütün, Nelson, D., Fingerhut, M., Jeigh L, Tak, S., & Philips, S. (2005). Estimating the global burden of low back pain attributable to combined occupational exposures. *Am J Ind Med*, 48(6), 459–469.
 - [54] Rajagopal, T. (2003). Musculoskeletal disorders. *Indian J Occup Environ Med*, 4, 2–3.
 - [55] Roffey, D. M., Wai, E. K., Bishop, P. D., Kwon, B. K., & Dagenais, S. (2010). Causal assessment of occupational standing or walking and low back pain: results of a systematic review. *The Spine Journal*, 10(3), 262–272.

-
- [56] Rudy, T. E., Weiner, D. K., Lieber, S. J., Slaboda, J., & Boston, R. J. (2007). The impact of chronic low back pain on older adults: a comparative study of patients and controls. *Pain*, 131(3), 293–301.
 - [57] Saetung, S., & Chailurkit, la-or. (2013). Thai traditional massage increases biochemical markers of bone formation in postmenopausal women: A randomized crossover trial. *BMC Complementary and Alternative Medicine*, 13(1), 69.
 - [58] Schofield, D. J., Shrestha, R. N., Passey, M. E., Arul, E., & Fletcher, S. L. (2008). Chronic disease and labour force participation among older Australians. *The Medical Journal of Australia*, 189(8), 447–450.
 - [59] Sengupta, P. (2012). Health impacts of yoga and pranayama: A state-of-the-art review. *Int J Prev Med.*, 3(1), 444–458.
 - [60] Shahin, Md. A., Rijwan, B., Haq, S. A., & Mohammad, M. Z. (2022). Risk factors of non-specific low back pain in a rural community of Bangladesh: A case-control study. *F1000Research*, 11, 871.
 - [61] Sharma, V., Das, S., Mondal, S., Goswami, U., & Gandhi, A. (2005). Effect of Sahaj Yoga on Depressive disorders. *Indian J Physiol Pharmacol*, 49(4), 462–468.
 - [62] Sherman, K. J., Cherkin, D. C., Wellman, R. D., Cook, A. J., Hawkes, R. J., Delaney, K., & Deyo, R. A. (2011). A Randomized Trial Comparing Yoga, Stretching, and a Self-care Book for Chronic Low Back Pain. *Arch Intern Med*, 171(22), 2019–2026.
 - [63] Sherman, K. J., Wellman, R. D., Cook, A. J., & Cherkin, D. C. (2013). Mediators of Yoga and Stretching for Chronic Low Back Pain. *Evid Based Complement Alternat Med*, 2013, 130818.
 - [64] Simmonds, M., Lee, C., Etnyre, B., & Morris, G. (2012). The influence of pain distribution on walking velocity and horizontal ground reaction forces in patients with low back pain. *Pain Res Treatment*, 2012, 214980.
 - [65] Smith, C., Hancock, H., Blake-Mortimer, J., & Eckert, K. (2007). A Randomized Comparative Trial of Yoga and Relaxation to Reduce Stress and Anxiety. *Complementary Therapies in Medicine*, 15, 77–83.
 - [66] Srivastava, A., Kumar, A., Mallik, A. K., Sinha, S., & Pandey, S. K. (2019). Yoga as Therapeutics in Obesity Management: An Observational Study. *Indian Journal of Physical Medicine & Rehabilitation*, 30(2), 46–48.
 - [67] Sunisa, C., Pornnapa, S., & Sari, A. (2020). Risk Factors Associated with Work-Related Low Back Pain Among Home-Based Garment Workers. In T. Ahram, Karwowski, Vergnano, Leali, & Taiar (Eds.), *Intelligent Human Systems Integration*. Springer.
 - [68] Suzuki, H., Kanchiku, T., Imajo, Y., Yoshida, Y., Nishida, N., & Taguchi, T. (2016). Diagnosis and Characters of Non-Specific Low Back Pain in Japan: The Yamaguchi Low Back Pain Study. *PLOS One*, 0160454, 1–13.
 - [69] Tekur, P., Nagaratna, R., Chametcha, S., Hankey, A., & Nagendra, H. (2012). A comprehensive yoga programs improves pain, anxiety and depression in chronic low back pain patients more than exercise: an RCT. *Complement. Ther. Med*, 20(3), 107–118.
 - [70] Tekur, P., Singphow, C., Nagendra, H., & Raghuram, N. (2008). Effect of Short-term Intensive Yoga Program on Pain, Functional Disability and Spinal Flexibility in Chronic Low Back Pain: A Randomized Control Study. *J Altern Complem Med*, 14, 637–644.
 - [71] Tilbrook, H. E., Cox, H., Hewitt, C. E., Kang'ombe, A. R., Chuang, L.-H., Jayakody, S., Aplin, J. D., Semlyen, A., Trehwela, A., Watt, I., & Torgerson, D. J. (2011). Yoga for Chronic Low Back Pain- A Randomized Trial. *Annals of Internal Medicine*.
 - [72] Ülger, O., & Yağlı, N. V. (2011). Effects of yoga on balance and gait properties in women with musculoskeletal problems: a pilot study. *Complement. Ther. Clin. Pract*, 17(1), 13–15.
 - [73] van Valburg, A., van Roy, H., Lafeber, F., & Bijlsma, JW. (1998). Beneficial effects of intermittent fluid pressure of low physiological magnitude on cartilage and inflammation in osteoarthritis. An in vitro study. *J Rheumatol*, 25(1), 515–520.
 - [74] Vijayaraghava, A., Doreswamy, V., Narasipur, O. S., Kunnavil, R., & Srinivasamurthy, N. (2015). Effect of Yoga Practice on Levels of Inflammatory Markers After Moderate and Strenuous Exercise. *J Clin Diagn Res.*, 9(6), CC8–CC12.
 - [75] Vincent, H., George, S., Seay, A., Vincent, K., & Hurley, R. (2014). Resistance exercise, disability, and pain catastrophizing in obese adults with back pain. *Med Sci Sports Exerc*, 46, 1693–1701.

- [76] Viravud, Y., Apichartvorakit, A., Mutirangura, P., & Plakornkul, V. (2017). The anatomical study of the major signal points of the court-type Thai traditional massage on legs and their effects on blood flow and skin temperature. *Journal of Integrative Medicine*, 15(2).
- [77] Wai, E. K., Roffey, D. M., Bishop, P., Kwon, B. K., & Dagenais, S. (2010). Causal assessment of occupational lifting and low back pain: results of a systematic review. *The Spine Journal*, 10(6), 554–566.
- [78] Wamontree, P., Kanchanakhan, N., Eungpinichpong, W., & Jeensawek, A. (2015). Effects of traditional Thai self-massage using a Wilai massage stickTM versus ibuprofen in patients with upper back pain associated with myofascial trigger points: a randomized controlled trial. *Journal of Physical Therapy Science*, 27, 3493–3497.
- [79] Wang, Y., Lu, S., Wang, R., Jiang, P., Rao, F., & Wang, B. (2018). Integrative effect of yoga practice in patients with knee arthritis: A PRISMA-compliant meta-analysis. *Medicine (Baltimore)*, 97(31), e11742.
- [80] Wasser, J. G., Vasilopoulos, T., Ann, Z. L., & Vincent, H. K. (2017). Exercise Benefits for Chronic Low Back Pain in Overweight and Obese Individuals. *PM&R*, 9(2), 181–192.
- [81] Wilder, D. (1993). The biomechanics of vibration of low back pain. *American Journal of Industrial Medicine*, 23(4), 577–588.
- [82] Wilkie, D., Lovejoy, N., Dodd, M., & Tesler, M. (1990). Cancer Pain Intensity Measurement: Concurrent Validity of Three Tools—Finger Dynamometer, Pain Intensity Number Scale, Visual Analogue Scale. *The Hospice Journal*, 6(1), 1–13.
- [83] Zheng, Z., Wang, J., Gao, Q., Hou, J., Ma, L., CongboJiang, & Chen, G. (2012). Therapeutic evaluation of lumbar tender point deep massage for chronic non-specific low back pain. *Journal of Traditional Chinese Medicine*, 32(4), 534–537.