วารสารวิทยาศาสตร์และเทคโนโลยีการกีฬา ปีที่ 16 ฉบับที่ 1, กรกฎาคม 2559
Journal of Sports Science and Technology Volume 16, No. 1, July 2016

นิพนธ์ต้นฉบับ (Original article)
สรีรวิทยาการออกกำลังกายและกีฬา (Sports and Exercise Physiology)

ผลของการฝึกหฐโยคะแบบประยุกต์ 8 สัปดาห์ ต่อความแปรปรวนของอัตราการเต้นของหัวใจ และการตอบสนองต่อความเครียดในคนงานที่ประสบอันตรายเนื่องจากการทำงาน

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บทคัดย่อ

วัตถุประสงค์ของการศึกษาคือ ๑)ศึกษาผลของการฝึกหฐโยคะเป็นเวลา 8 สัปดาห์ ในคนงานที่ประสบอันตรายเนื่องจากการทำงาน ๒) วัดความแปรปรวนของอัตราการเต้นของหัวใจ (HRV) การตอบสนองต่อความเครียด และสมรรถภาพร่างกายที่เปลี่ยนแปลงไปในคนงานที่ประสบอันตรายเนื่องจากการทำงาน (IW) ผู้ร่วมการวิจัย จำนวน 26 คน แบ่งจำนวนเท่าๆกันเป็น คนงานกลุ่มควบคุม (CN) และคนงานกลุ่ม IW อายุ 18-60 ปี โดยผู้ร่วมวิจัยจะถูกวัดHRV คลื่นไฟฟ้ากล้ามเนื้อ อัตราการหายใจ อุณหภูมิทางผิวหนัง การนำความร้อนของผิวหนัง และวัดสมรรถภาพทางกาย ได้แก่ ร้อยละไขมัน ความอ่อนตัว การทำงานของปอดและแรงบีบมือ จากนั้น กลุ่มIW จะถูกแบ่งออกเป็น กลุ่มที่เข้าร่วม(YIW) และไม่เข้าร่วม (CIW) การฝึกหฐโยคะแบบประยุกต์ วันละ 60 นาที 3 วันต่อสัปดาห์เป็นเวลา 8 สัปดาห์ จากนั้นตัวแปรต่างๆจะถูกวัดอีกครั้ง ผลการศึกษาพบว่า กลุ่มIW มีการเพิ่มขึ้นของอัตราส่วน LF/HF ของ HRV =2.41 ค่าการนำความร้อนของผิวหนัง =2.18 μS) เมื่อเปรียบเทียบกับกลุ่ม CN (=1.61, =2.24 μS ตามลำดับ) การฝึกหฐโยคะเป็นเวลา 8 สัปดาห์ พบว่ากลุ่ม YIW มีการเพิ่มขึ้นของสมรรถภาพทางกาย ในส่วนการทำงานของปอด แรงบีบมือ ความอ่อนตัวของร่างกาย และร้อยละของไขมันใต้ผิวหนังลดลง การศึกษานี้จึงสรุปได้ว่า คนงานที่ประสบอันตรายเนื่องจากการทำงานมีความเครียดมากกว่าปกติ และการฝึกหฐโยคะแบบประยุกต์เป็นเวลา 8 สัปดาห์ สามารถเพิ่มระดับสมรรถภาพทางกาย แต่ไม่สามารถพัฒนา HRV และการตอบสนองต่อความเครียดได้

(Journal of Sports Science and Technology 2016; 16(1) : 55-64)

คำสำคัญ: ความแปรปรวนของอัตราการเต้นของหัวใจ (HRV), คนงาน, การฝึกหฐโยคะแบบประยุกต์

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EFFECTS OF AN EIGHT WEEK MODIFIED HATHA YOGA ON THE HEART RATE VARIABILITY & STRESS RESPONSE IN INDUSTRAIL INJURED WORKERS

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ABSTRACT

The purposes of this study were 1) to evaluate the effects of modified hatha yoga on the injured workers after training for 8 weeks, and 2) to measure heart rate variability (HRV), stress responses, and physical fitness changes in the industrial injured workers. Twenty-six subjects (13 injured workers (IW) and 13 control normal workers (CN), aged between 18 to 60 years, volunteered to participate in this study. All participants were measured HRV, stress responses parameters including electromyography (EMG), respiratory rate, skin temperature and skin conductance. IW group were further divided into two groups; hatha yoga injured workers (YIW) (n=7) and control injured workers (CIW) (n=6). YIW group performed 60-minute/day, 3 days/week for 8 weeks of modified hatha yoga and then all parameters were measured again. Results showed that IW group had a significant increase in LF/HF ratio of HRV (2.41) and skin conductance (2.18 μS) compared to the CN group (HRV= 1.61, skin conductance = 1.24 μS) ($p < 0.05$).

Conclusion: The injury from industrial work disturb balance of PNS and SNS activity. And the 8 week modified hatha yoga could not improve HRV and stress response in YIW group.

(Journal of Sports Science and Technology 2016; 16(1) : 55-64)

Keywords: Heart rate variability, Workers, Modified hatha yoga

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INTRODUCTION

Stress is one of factors that affect ANS balance by increased sympathetic nervous system (SNS) and reduced parasympathetic nervous system (PNS) activity.[1] The hypothalamic– pituitary–adrenal (HPA) axis and SNS are triggered by the stressor (a physical or psychologic demand), resulting to a cascade of physiologic, behavioral, and psychologic effects via the release of cortisol and catecholamine (epinephrine and norepinephrine). This response leads to the mobilization of energy needed to combat the stressor through the classic ‘‘fight or flight’’ syndrome. Over time, the continue state of hypervigilance resulting from repeated firing of the HPA axis and SNS can lead to imbalance of the system and ultimately symptoms of disorder such as depression, post-traumatic stress, hypertension, neurologic disorder etc.[2] The stress can comes from many factors, mostly caused by the illness, the environment, the family, the individual acceptance, and also from the economic conditions.[3] An occupational injury is bodily damage resulting from working which can cause the loss of organs, disability, and even death in an injured worker. The impact of this injury not only on workers' health, but also on productivity, loss of time, loss of workers in occupations, loss of healthcare property, and damage for economy. The normal worker usual gets stress caused by hardly work, less compensation, and low welfare. In fact, when they are injured at work and became disabled, they suffer through loss of income which is due to absence from work as well as the illness itself. These may cause the injured workers to have more stress than the others .[4,5] HRV is indicator of stress when the body affect by stress, it increased the high frequency power of heart rate variability that means lower in the parasympathetic activity.[6, 7] Yoga is an ancient knowledge designed to make balance and health to the physical, mental, emotional, and spiritual proportions of the individual. It synchronized between breathing and movement.[8, 9] Telles et al. found dhyana (yoga meditative) decreased in the low frequency power and increased in the high frequency power that associated with parasympathetic activity had increased.[7] Recently work reported that an 8-week modified hatha yoga training experience exerted therapeutic effects on physical fitness variables including flexibility of lower back and hamstrings, hand grip strength and vital capacity, but not on stress level in injured workers.[10] We therefore recommended further study to confirm this finding by using the other stress measurement tools. The aim of this study was to investigate the effects of 8 weeks of modified hatha yoga on HRV and physiological stress response parameters including respiratory rate, skin conductance, skin temperature, and EMG in industrial injured workers using a HRV biofeedback device.

METHOD

Twenty-six subjects volunteered who had the moderate stress level (stress test score 25>), to this study. All subjects were divided to two groups; thirteen injured workers (IW), and thirteen control normal (CN). And subject who could not complete the training program was excluded from this study. Baseline data was collected from all subjects before the injured workers recruited into experimental. The CN group was worker

who got involved with machines in any factory located in Nakorn Pathom province. The IW group was patient in the Industrial Rehabilitation Center Workers, Social Security Office located in Pathum Thani province. They informed consent form was signed according to the Human Ethics Committee on Human Experimentation of Mahidol University. All physiological stress responses parameters were measured by used the Nexus 10 Mark II (Mindmedia, Netherland). Data were evaluated in a quiet and temperature-controlled room. Subjects were advised to refrain from drinking coffee before the day of assessment and avoided exercise for at least 24 hours prior to assessment. Repeated assessment was completed at precisely the same time of day and using the same procedures as the baseline assessment. Subjects were instructed not to speak and used a regular breathing during the assessment period. The data were recorded for 5-min, after 15 minutes of supine rest. Biotrace+ software (Mind media B.V., Netherland) was used to record all parameters.[11, 12] The modified hatha yoga used for this study was approved by two yoga instructor, who had international yoga certification, and the physician who was in field of disability.

The training protocol consisted of:

- Ujjayi Pranayama (Conqueror Breath in sit position)
- Janu Sirsasana (Head-to-Knee Forward Bend in sit position)
- Paschimottanasana (Seated Forward Bend)
- Virasana (Hero Pose)
- Bhujangasana (Cobra Pose)
- Makarasana (Crocodile Pose)
- Balasana (Child Pose)
- Supta Baddha Konasana (Reclining Bound Angle)
- Savasana (Corpse Pose)

In YIW group (n=6), subjects were trained modified hatha yoga for 8 weeks; 60 min/day and 3 days/week, whereas in CIW group (n=7), subjects were instructed to maintain normal physical activity and did not participate in extremely exercise during the study period. At the end of week 8th, subjects were assessed and recorded their physiological response variables again.

All data presented in mean ± SD. Komogorov – Smirnov test was used for the data normal distribution test. Independent *t*-test was used to compare difference baseline and interventions between groups. Dependent paired *t*-test was used to compare difference within control and hatha yoga injured worker groups. The statistical tests were performed using a SPSS software program. Significance was set at *p*–value less than 0.05.

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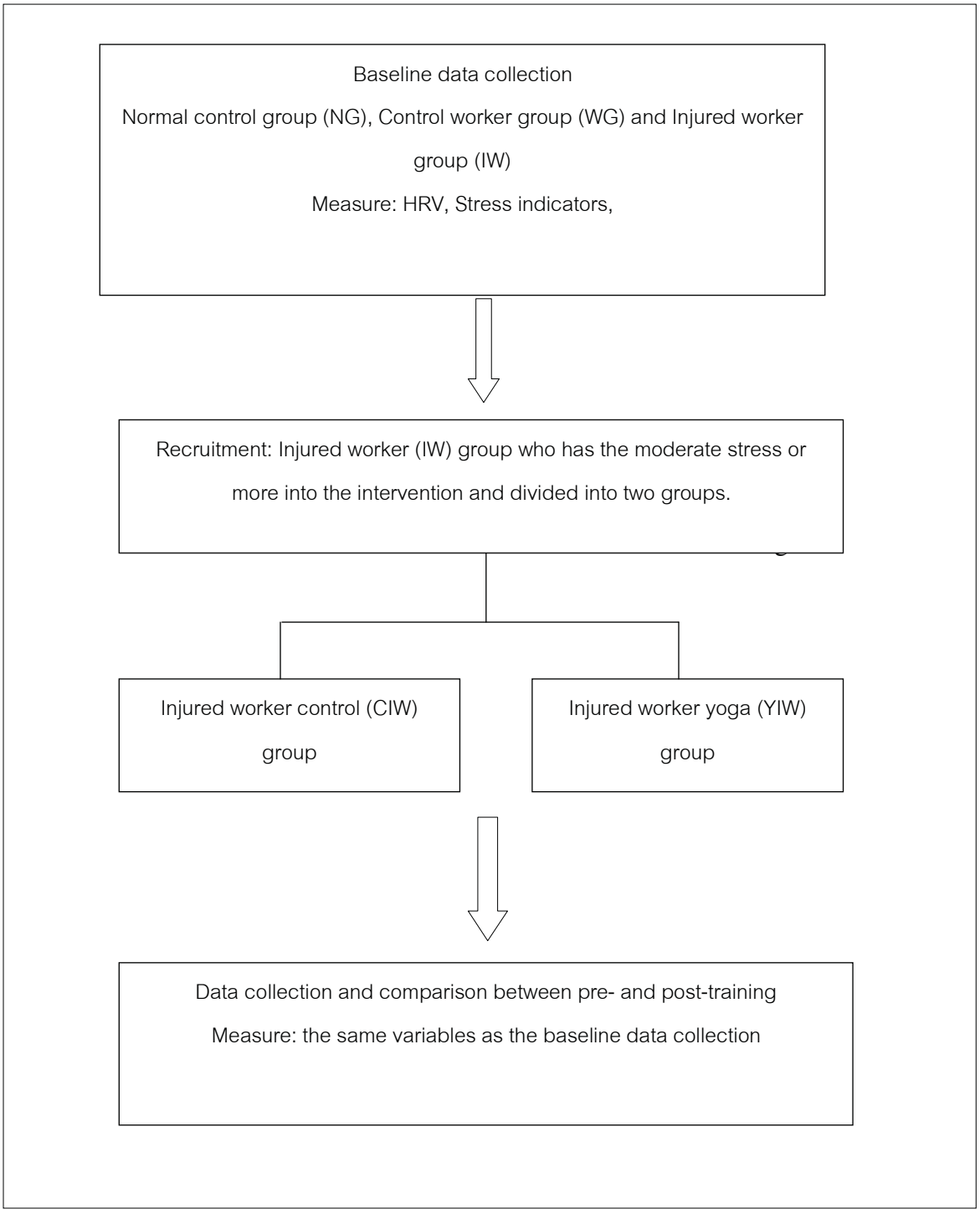

Figure 1 Overall view of experimental protocol

RESULT

Table 1 showed the baseline data of the general characteristics between of CN and IW had no significant difference. They were homogeneous.

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Table 1 Baselines characteristics of control normal (CN) and injured worker (IW) groups. The data were mean±SD.

Variables	CN (n=13)	IW (n=13)
Age (y)	37 ± 12	38 ± 12
Women : Men	5 : 8	3 : 10
Body weight (kg)	67 ± 8	65 ± 9
Height (cm)	164 ± 8	168 ± 8
Body Mass Index (kg/m^2)	25.31 ± 2.76	23.22 ± 3.9
Resting heart rate (bpm)	70 ± 10	70 ± 7
Systolic blood pressure (mmHg)	118 ± 10	118 ± 8
Diastolic blood pressure (mmHg)	78 ± 8	75 ± 7

The participants who volunteer to training program were divided into two groups equally number and similar in the disability showed in Table 2.

Table 2 Baselines characteristics of control (CIW) and hatha yoga (YIW) injured worker groups.

Variables	CIW (n=7)	YIW (n=6)
Age (y)	32 ± 9	45 ± 11
Women : Men	1 : 6	2 : 4
Body weight (kg)	62 ± 5	69 ± 11
Height (cm)	171 ± 9	165 ± 5
Body Mass Index (kg/m2)	21.41 ± 3.31	25.32 ± 3.67
Resting heart rate (bpm)	72 ± 7	67 ± 7
Systolic blood pressure (mmHg)	115 ± 5	122 ± 10
Diastolic blood pressure (mmHg)	73 ± 5	77 ± 9
Types of injury		
G81.9 Hemiplegia, unspecified	1	-
G82.2 Paraplegia, unspecified	3	2
Z89.0 Acquired absence of finger(s) [including thumb], unilateral	2	-
Z89.1 Acquired absence of hand and wrist	-	1
Z89.2 Acquired absence of upper limb above wrist	-	1
Z89.3 Acquired absence of both upper limbs [any level]	-	1
Z89.4 Acquired absence of foot and ankle	1	1

G – Code to identify the person who had the injury of brain. Z – Code to identify the person who had the acquired injury of body.

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Table 3 Comparison of heart rate variability (HRV) variables and stress indicators between control normal (CN) and injured worker (IW) groups.

Variables	CN (n=13)	IW (n=13)
HRV variables		
■ VLF (ms^2)	1174.9 ± 368.1	2102.1 ± 703.6
■ LF (ms^2)	3141.4 ± 809.1	6290.3 ± 2320.2
■ HF (ms^2)	2890.4 ± 584.3	3008.9 ± 776.5
■ LF/HF (ratio)	1.61 ± 0.32	2.41 ± 0.6*
■ %LF	44.00 ± 4.30	48.36 ± 4.61
■ %HF	39.57 ± 4.80	32.98 ± 4.01
Stress indicators		
■ EMG Mean frequency (Hz)	71.39 ± 1.84	70.53 ± 1.88
■ Respiratory rate (bpm)	17.33 ± 1.08	18.00 ± 1.25
■ Skin conductance (μS)	1.24 ± 0.19	2.18 ± 0.42*

*Significant difference compared between groups ($p < 0.05$).

Baseline data of the CN group and the IW group presented as mean ± standard deviation. VLF stands for the very low frequency, LF stands for the low, HF stands for the high frequency, LF/HR stands for the ratio of the LF and HF, %LF (percentage) stands for the percentage of LF in the entire spectrum, %HF stands for the percentage of HF in the entire spectrum.

Table 4 Comparison of HRV variables and stress indicators between pre-test and post-test of control (CIW) and hatha yoga (YIW) injured worker groups.

Variables	CIW (n=7)		YIW (n=6)	
	Pre-test	Post-test	Pre-test	Post-test
HRV variables				
■ VLF (ms^2)	645.78 ± 483.61	2201.28 ± 3380.13	531.95 ± 560.03	2273.14 ± 1961.47
■ LF(ms^2)	2564.36 ± 1741.9	4790.82 ± 6284.92	1462.25 ± 2154.73	8057.28 ± 10993.5*
■ HF(ms^2)	1999.97 ± 1135.85	2752.37 ± 2541.46	1234.45 ± 882.91	5623.38 ± 5779.5
■ LF/HF	1.5 ± 0.74	1.92 ± 2.39	0.9 ± 0.75	2.47 ± 2.64
■ %LF	48.2 ± 15.02	43.87 ± 21.84	34.9 ± 12.81	48.31 ± 16.19
■ %HF	38.97 ± 17.59	38.51 ± 17.69	46.13 ± 12.42	33 ± 18.1
Stress indicators				
■ EMG Mean frequency	71.59 ± 6.54	72.18 ± 8.15	68.88 ± 6.58	68.96 ± 5.84
■ Respiratory rate	20.33 ± 6.54	18.13 ± 4.75	20.89 ± 6.02	17.41 ± 5.2
■ Skin conductance (μS)	4.69 ± 4.21	1.93 ± 1.94	1.64 ± 1.37	1.88 ± 1.06

*Significant difference compared between Pre-test and Post-test ($p < 0.05$).

Data presented as mean ± standard deviation. VLF stands for the very low frequency, LF stands for the low, HF stands for the high frequency, LF/HR stands for the ratio of the LF and HF, %LF (percentage) stands for the percentage of LF in the entire spectrum, %HF stands for the percentage of HF in the entire spectrum.

DISCUSSION

Effects of 8 weeks of modified hatha yoga training on HRV variables in injured workers 1. HRV response to the modified hatha yoga in injured workers

Low Frequency (LF) - Low Frequency is a band of power spectrum range between 0.04 and 0.15 Hz that show both activity of the sympathetic system and the parasympathetic system also show the activity of the baroreflex function. When the participant was relaxed with a gradual and deep breathing, LF values can represented that the increasing of the parasympathetic system rather than the sympathetic activity.

High Frequency (HF) - High Frequency is a band of power spectrum range between 0.15 and 0.4 Hz that effect by methods regulating gas exchange efficiency, respiratory sinus arrhythmia and function of the Vagus nerve. This measure reflects both sympathetic and parasympathetic activities.[9, 13]

Low HRV indicated higher the sympathetic activity while high HRV indicated higher the parasympathetic activity; low HRV is an established predictor of cardiovascular disease and number of death rate.[6, 11, 14]

Previous study of Satyapriya and co-worker (2009) found that the integrated yoga sessions could increase the HF, especially *pranayama*, breathing exercise, can stimulate the parasympathetic tone by increasing the nerve impulse from the vagus nerve and then slow the HR down in the pregnant women. [9, 15]

In this study, the increasing in LF of HRV variables showed the increasing of SNS activity that might indicate yoga practice for 8 weeks was not enough to improve autonomic regulatory functions. Several yoga studies reported that more yoga practices in the breathing-control, more improvement of the sympathovagal balance[7, 9, 17] This may explain our finding that component of modified hatha yoga in this study had only one *pranayama* (Ujjayi Pranayama; Congueror Breath in sit position) practice which may not strong enough to stimulate the vagal tone of the parasympathetic activity.

2. Stress Indicators response to the modified hatha yoga in injured workers

When body got stress it stimulated the adrenal medulla that increased the vasodilation in peripheral vessel that decreased blood flow and heat to the limbs, it decreased the skin resistance of skin to electricity.[18]

However there were no significant differences in the stress indicators indicated that an 8-week modified hatha yoga training, especially *pranayama* (meditation method by control breathing) is not intense enough to be changed in physiological stress responses of the YIW groups. The effect of the modified hatha yoga still unclear.

CONCLUSION

This study clearly shows that the injury workers have more stress than the control workers as revealed by increasing LF/HF ratio as well as decreasing in the skin temperature and had trend of increasing in skin conductance, indicate stress related injury from work could disturb the balance between sympathetic and parasympathetic activity implicated shifting the autonomic balance to the sympathetic branch of the ANS and increase the sensitivity of arousal response. Consistent with the previous study, this study confirms that an 8-week modified hatha yoga training have beneficial effects on improving flexibility of lower back and hamstrings, hand grip strength and vital capacity, but not sufficient enough to improve autonomic regulatory function measuring by HRV and physiological stress response of the injured workers.

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