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Research Article

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Effects of Workplace Stress on Hong Kong Employees' Heart Rate Variability

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Abstract

Research on workplace stress measurements varied without much accuracy and effectiveness. The objective of this study was to introduce a new quantitative, assessment tool emWave Pro Plus (Institute of Heart Math) and to compare Heart Rate. Variability (HRV) results with the Personal and Organizational Quality Assessment (POQA) and the Perceived Stress Scale (PSS). Eighty-five (85) full-time employees, who were working at least 40 hours per week in a large corporation, participated in this study. Firstly, signify cant negative correlations were found between Subjective Stress and HRV measures: Perceived Stress and 5-minute Mean Inter-Beat-Interval (IBI), r=-0.217; Perceived stress and 5 min SDNN, r=-0.255 and Perceived stress and Ln 5 min RMSSD (Ln means the natural logarithm), r=-0.282. Secondly, significant negative correlations were found between age and the HRV measures: 1-minute SDNN (r=-.235, p<0.01); 5-minute SDNN (r=-0.290, p<0.01); 5-minute RMSSD (r=-0.395, p<0.01); Total Power (r=-0.272, p<0.05); Very Low Frequency (r=-0.215, p<0.05) and High Frequency (r=-0.402, p<0.01). Thirdly, significant negative correlation was found between Normalized Coherence and Relational Tension (r=-0.222, p<0.05). Additionally, significant positive correlations were found between Emotional Stress and the Mean Heart Rate Range (MHRR), r=0.216 and between Intention to Quit and 5-minute Ln Very Low Frequency (VLF), r=0.234. The research shows promising results and future studies should continue to tap into HRV as an objective measure of mental health and workplace stress.

Introduction

Research on workplace stress measurements varied without much accuracy and effectiveness [1-3]. One of the gaps is the usage of outdated assessments to measure workplace stress. Moreover, there has been an extensive use of psychometric measures on workplace stressors that are self-reported [4,5] without the use of physiological measurements [6]. Hence, Lazarus (1990) argued that the best method to measure stress effectively is by using a mixed method of both empirical and interpretive surveys which give the researcher a well-rounded picture of participants' subjective experiences and state [7]. Researchers report that Heart Rate Variability (HRV) is an important biomarker (primary mediator of neurophysiologic pathway), one of the variables in the Allosteric Load Index that is easily assessable and accessible to measure workplace stress.

This research studied workplace stress as experienced by full-time employees in an actual large corporation. The purpose of the quantitative correlation research was to introduce a new quantitative measurement tool such as emWave Pro Plus in the workplace and to compare HRV results with two other sets of quantitative self-reported measurements of stress. The following four research questions were examined:

1. In what way can HRV be used to accurately measure long-term effects of workplace stress in Hong Kong?
2. What are the effects of workplace stress in Hong Kong on HRV?
3. In what way does HRV compare with self-reports of stress in Hong Kong?
4. What is the overall level of comfort a typical Hong Kong employee experiences?

These questions were investigated with Pearson correlation analysis of HRV measures (IBI, SDNN, RMSSD, MHRR, normalized coherence, Total power, Very low frequency, Low frequency and High frequency power along with the Low frequency/High frequency ratio), POQA and PSS scales using SPSS Version 22.0 (IBM Corp, 2013) to examine the relationships between the new HRV measurements and the two quantitative self-reported perceived stress data.

Research Method

As the research study was to explore the effects of workplace stress on Heart Rate Variability (HRV), which utilized the power spectral components and key time domain measures of heart rate variability to analyze heart rate data after the employee had self-reported his or her level of stress over two scales: one was the Personal and Organizational Quality Assessment (POQA) and the other was the Perceived Stress Scale (PSS) [8]. After these assessments were completed, a correlation between the Heart Rate Variability (HRV) and both POQA and PSS was conducted. Hence, this study adopted a Quantitative research design to quantify relationships between or among variables - the independent or predictor variable (s) and the dependent or outcome variable (s). In this case, PSS and POQA are the dependent variables while HRV measurements such as SDNN, RMSSD, MHRR and normalized coherence are the independent variables [9]. Researchers in correlational studies have collected two or more variables for a specific group of people where the data are numbers that reflect specific measurements of the variables in question [10]. In this study, HRV, quantified by the four variables (SDNN, RMSSD, MHRR and normalized coherence) was correlated

with the perceived stress quantified by the POQA-R4 rating scale as well as the Perceived Stress Scale.

Participants

The chosen study population was made up of full-time employees in a large corporation of over 500 employees (hereinafter referred to as "Company X"). All employees of the company were welcomed to participate. The full-time participants were working at least 40 hours per week. Company X employs over 500 office work employees. Company X operates out of different locations in Hong Kong. The research was conducted in an air-conditioned room on the 19th floor within the temperature between 22-26°C in one of the locations in which Company X operates in Hong Kong. The building is unobstructed by the external traffic within a large urban area that has a population density of 639,900.

Study Sample

Inclusion/Exclusion criteria

Eligible employees were: full-time employees working at least 40 hours per week for Company X; male or female; at least 18 years of age; and able to read, write, and understand English. However, employees who had taken any kind of medication that might influence the results or caffeinated/alcohol beverages within 2 hours prior to the session were excluded from the study.

Sampling procedures

After the participating employees of Company X signed the informed consent forms, they accessed the online POQA questionnaire as well as filling up the PSS questionnaire. Once the questionnaires were filled up, the researcher performed biometric tests on the employee using the emWave Pro Plus.

Study Setting

The study was performed between 08:00 a.m. and 08:00 p.m. in an air-conditioned room within the temperature range of 22-26°C. In general, this temperature range was acceptable for the study [11].

Instrumentation

Validity and Reliability

The primary purpose of this research study as mentioned previously was to introduce a new practical assessment, Heart Rate Variability (HRV) to assess employee stress in the workplace in Hong Kong, with a secondary purpose to explore the correlational ties between HRV quantitative measurements and other captured quantitative data on workplace stress of employees in Hong Kong. Subjective workplace stress measurements can have limited reliability and validity due to the likelihood of overestimating the answers and the risk of bias [12,13]. According to previous research, both subjective and objective aspects are required to measure workplace stress as they are interrelated [14-16].

It was of interest to investigate how well the POQA and PSS corresponded with an objective measure, which could reflect the balance between an employee's individual resources and demands of the workplace environment. A possible psychophysiological concept related to workplace stress is the Heart Rate Variability (HRV), which is an extensively accepted and validated objective measure reflecting of the healthy functioning, self-regulatory capacity, adaptability and resilience of one's body [17]. Moreover, a number of research studies have demonstrated HRV to be a strong independent predictor of future health [18-20]. Reduced HRV has been found in different cardiac pathologies and in patients under stress who suffer from anxiety, panic or worry; in patients with autonomic dysfunction, including asthma and depression; and in death from several causes [21-24]. Hence, HRV has been strongly recommended as the appropriate tool to assess the level of strain at work and recovery from work [15].

Most historical workplace stress researches that correlated HRV with workplace stress have shown a negative correlation between the variables. A few available studies have tested both objective and subjective measures to get a better prediction of the way to cope with workplace stress and to explore the relationship between HRV (both one- and five-minute recordings) and PSS. However, no studies have explored the relationship between HRV and POQA. Fohr et al. (2015) investigated how subjective self-reported stress (PSS) is associated with objective heart rate variability (HRV)-based stress and have found that subjective self-reported stress is associated with objective physiological stress. Hence, Fohr et al. suggest that objective stress assessment provides an additional aspect to the evaluation of stress.

Da Silva has assessed the correlation between PSS and HRV parameters [25]. They reported that decreased heart rate variability (HRV) is associated to increased mortality rates in certain heart diseases. Moreover, the correlation between psychological stress, measured by the perceived stress scale (PSS-14), and HRV parameters obtained during 5 minute at rest was evaluated. Data from 35 healthy young volunteers showed a significant correlation between PSS-14 scores and Low Frequency-LF (ms2) by frequency domain HRV analysis. Other variables such as High Frequency and Standard Deviation of R-R intervals had also negative coefficients but did not have any significant correlation with PSS-14. No correlation between PSS-14 and sympathovagal balance parameters was found. Data interpretation demonstrated that an increase in perceived stress was correlated to a decrease in heart rate variability, which may suggest an important mechanism in cardiovascular pathophysiology that is potentially valuable for further research.

Orsila [26] correlated perceived mental stress during occupational work with heart rate variability (HRV), using a traditional questionnaire and a novel wristop heart rate monitor with related software. A single survey item was used to assess perceived mental stress, which was elicited on a visual analog scale (from 0—very little stress to 10-very high stress) during the workday. Subjects who scored 6 or more were considered stressed. The periods studied were formed on the basis of the information written in the subjects' study diaries. The same diary data was also used to verify significant variations in HRV. The aim was to find HRV parameters useful for mental stress detection. The researchers found the highest correlation between perceived mental stress with the differences between the values of triangular interpolation of (RR) interval histogram (TINN) and the root mean square of differences of successive RR intervals (RMSSD) obtained in the morning and during the workday ($r = -.73$ and $r = -.60$, respectively). The analysis shows that as the RMSSD and TINN value differences increase from night to morning, the stress decreases.

HRV has been examined to provide an accurate and reproducible quantitative measure of mental health in social, emotional and cognitive research, as HRV is affected by blood pressure and respiration [27]. A risk mentioned by Quintana and Heathers is

that "if the direction of causality between experimental task and the coordinated response within cardiac, circulatory and respiratory variables is poorly understood simple relationships between task and output changes may be obscured". Often uncontrolled measures like medicine, food and water consumption, a full bladder, and time of day may severely influence HRV and should be considered in future experiments [27].

To summarize, due to the increased need to utilize both subjective and objective aspects to measure workplace stress, it is of paramount interest to introduce a new practical assessment, Heart Rate Variability (HRV) to assess long-term effects of employee stress in the workplace in Hong Kong. Furthermore, this research has explored the correlational ties between HRV quantitative measurements and other captured quantitative data (PSS, POQA) on workplace stress of employees in Hong Kong. The aim of this research study was to examine whether heart rate variability (HRV) was related to workplace stress, using PSS as well as POQA, and could therefore be a valid biometric stress measure in future workplace stress measurements on a global basis. The hypothesis was that HRV would be negatively correlated with PSS and POQA scales indicating high stress.

Instruments

Two scales were used to collect data on the dependent variables perceived stress scale (PSS) as well as Personal and Organizational Quality Assessment (POQA). These scales represented operationalization of the dependent variables in the conceptual framework, and both of them had sound psychometric properties.

Personal and Organizational Quality Assessment-Revised 4 Models. The POQA-R4 is an instrument developed by researchers at the Institute of Heart Math. It contains 49 questions on four major scales of workplace quality directly related to health and workplace performance [28]. Barrios-Choplin and Atkinson (2000) describe that the instrument gathers self-reported information on socio-demographic and key psychological and workplace elements associated with the overall quality and effectiveness of the individual and the organization. The instrument uses eight items of socio-demographic information about the respondents' characteristics which include gender, age, marital status, employment status, and level of education, the number of hours worked per week, the number of years in the company, and the number of years in the current role [28]. The 49 items are divided into four factors which measure emotional vitality, emotional stress, organizational stress, and physical symptoms of stress. They have been empirically validated and found to be reliable based on a measurement study conducted on the existing POQA-R database of 2,540 employed adult respondents [28].

At the primary scale level (the four factors), the minimum number of items assigned to a factor was 8 and the maximum number of items assigned was 15; at the subscale level (the sub-factors or components within a factor); the range of items assigned to a given subscale was from 2 to 8. Overall, under this new framework, 6 of the 9 multi-item subscales were measured by 5 or more items.

Two statistical analyses were conducted to verify the measurement validity and reliability. In the first analysis, the seven scales and their associated subscales were subjected to an analysis of internal consistency of measurement using Cronbach's coefficient alpha (α). The results of the four primary scales showed that all constructs exceeded the criterion for technical adequacy ($\alpha > 0.75$): the alpha coefficients ranged from 0.76, for Organizational Stress, to 0.92 for Emotional Vitality and Emotional Stress. The results for the nine multi-item subscales showed that, with one exception (Relational Tension, $\alpha = 0.69$), these constructs also achieved or exceeded the criterion for technically adequate measurement reliability. Across the other eight multi-item subscales the alpha coefficient ranged from 0.76, for Health Symptoms, to 0.90, for Emotional Buoyancy, Intention to Quit, and Anxiety/Depression.

In the second analysis, all 49 items were factor analyzed (results not shown) to compare the item classifications resulting from the factor analysis with their nominal designation into the four primary scales and nine multi-item subscales of the POQA-R4's. With a few exceptions, the factor analysis item classifications corresponded to the nominal classification of the items into the categories for the primary scales. Overall, the results from both statistical analysis procedures confirm the validity of the items assignment to the scales and subscales and also confirm that the measurement reliability is more than technically adequate. In short, all of the available statistical evidence suggests that the measurement basis of the scales and subscales of the POQA-R4 framework appears to be psychometrically sound [28].

Perceived Stress Scale. The instrument used in this research to measure perceived stress was the Perceived Stress Scale (PSS); therefore the operation definition of perceived stress is the score on the PSS [29]. The PSS is a 10-item questionnaire that measures situations in the employee's life that are deemed stressful. This Likert-type instrument has each item scored 0 (never), 1 (almost never), 2 (sometimes), 3 (fairly often), to 4 (very often). An example question on the PSS is: In the past month, how often have you felt nervous and "stressed"? The total score possibility of the PSS is 56, with the higher the number, the greater the perceived stress. Scores near 13 are considered average, with scores greater than 20 indicating high stress. The Cronbach's alpha internal reliability of the PSS ranges from 0.84-0.86 [29].

The original PSS was a 14-item survey, with the subsequent development of 4-item and 10-item versions. The Cronbach's alpha coefficient for the internal reliability of the original PSS-14 was .75. In an exploratory factor analysis (EFA) of the PSS-14, Cohen and Williamson [29]. Eradicated four poorly performing items and the alpha coefficient increased to 0.84-0.86 on the newly developed PSS-10. Scores on the PSS-10 and PSS-4 demonstrated moderate convergent variability, but the PSS-4 scores performed with a relatively low reliability (60), with the result that the PSS-10 is the recommended perceived stress tool for this research [29,30]. Nevertheless, the PSS-4 is recommended only for situations where perceived stress measurements must be taken quickly [30].

emWave Pro Plus®. The emWave Pro Plus, designed by the Institute of Heart Math [31], is a computer software program that collects pulse data through a pulse sensor that can be plugged to a computer (Figure 10). The pulse sensor can be placed on the participant's earlobe or fingertip. The software then translates the information from the participant's heart rhythms into user-friendly graphics displayed on the computer monitor, which allows the researcher to watch in real time how thoughts and emotions are affecting the participant's heart rhythms (see Figure 10 for the example of

the computer monitor HRV reading). We learn that the emWave Pro Plus uses Photoplethysmography (PPG) technology which is based on the ability of hemoglobin to absorb light. As the amount of hemoglobin passes through the blood vessels changes due to the pulsatile nature of blood transportation, the amount of absorbed light also changes [32]. PPG technology is a reliable and valid method of capturing and quantifying real time HRV data, both resting HRV and deep breathing tests [32]. The pulse sensors used with the emWave Pro Plus during an individual's resting state (not ambulatory state) is identical to the recordings used with ECG [33]. For this research, HRV was measured by various parameters: SDNN, RMSSD, MHRR and normalized coherence. SDNN is the standard deviation of all mean normal-to-normal intervals measured in milliseconds. The measure reflects the ebb and the flow of all the factors that contribute to HRV and the heart's ability to respond to hormonal changes [17,34]. The RMSSD is the root mean square of successive differences between the normal heartbeats reflecting the short-term variance in heart rate. This value provides an estimate of the parasympathetic regulation of the heart [17,34]. MHRR is the mean heart rate range, which is the difference between the maximum and the minimum heart rate during each breathing cycle. The result is then expressed in beats per minute, as the mean of these heart rate differences for each measured cycle [17,34]. Finally, normalized coherence is a frequency domain measure of coherence where power in the coherence peak of the power spectrum density is divided by total power. This measure represents the ratio of coherence relative to total power and ranges from 0 – 100 [17]. Moreover, a coherent heart rhythm is visualized as a harmonic sine-wave-like signal with a narrow, high-amplitude peak in the low frequency (0.04-0.26 Hz) region of the HRV spectrum. Coherence is evaluated by detecting the maximum (coherence) peak in the 0.04-0.26 Hz range, calculating the integral in a window 0.030 Hz wide, centered on the highest peak in that region, and then calculating the total power of the entire spectrum [21]. The emWave Pro Plus is based on decades of research, incorporating the patented HRV measurement and has been used by tens of thousands of people in over 85 countries [31].

Data Collection

The Data Collection schedule was from 7 July 2017 to 30 September 2017.

Recruitment Processes

Once institutionally approved, employees of Company X were invited to participate in this study. A recruitment email was sent to employees of Company X a week before the start of the research study. The recruitment email briefly described the study, the inclusion/exclusion criteria, as well as the compensation (incentive) for the participants if they chose to participate and complete the research study requirements. The exclusion criteria was listed to inform potential participants the reasons why they would not qualify for this research study so that they didn't need to attend the Principal Researcher's visit, thus further protecting their privacy.

Informed Consent

At the visit by the Principal Researcher (PR) at one of the meeting rooms in the official premises of Company X, the participants who chose to participate completed the informed consent process before the data collection began. To fully complete this process, each participant read the informed consent form and was allowed to ask any additional questions regarding the study before signing and dating the informed consent form. Finally, the participant received a personal copy of his or her informed consent form. The PR determined if the participant was eligible for the research study by asking the participant whether he or she had consumed any caffeinated/alcohol beverages within 2 hours prior to the session.

During Data Collection

After the participant had signed the informed consent form, the research study data was collected in three sets: (1) Online survey – POQA, filled by the participants, (2) Pen-filling survey – PSS, filled by the participants and (3) Objective measurements (HRV) collected by the PR.

For HRV measurements, each participant was recorded individually in a quiet room, in a seated position. The participants received instructions for the test and the emWave Pro Plus pulse sensor was placed on their earlobes. Participants were instructed to remain seated, to stay relaxed and to refrain from making any significant or rapid body movements. Each session started with the five-minute resting state HRV assessment where the participant was told to breathe normally. Once the five minutes were up, participants were instructed to breathe according to the six-breath protocol. This breathing method provided a physiological challenge to assess the maximum HRV range (amplitude) during a one-minute period through deep breathing at the specific rate of five seconds of inhalation and five seconds of exhalation. Once achieved, there were six complete breath cycles over the course of one minute. The emWave Pro Plus software uses a breath-pacer to facilitate the regularity of the breathing. The entire minute has to be artefact-free so that the six cycles of the minimum and the maximum can be determined. Participants' compliance has to be closely monitored as insufficient deep breathing or poor synchronization with the breath pacer may result in lower test results. The average duration for each HRV testing session is seven minutes. The PR who administered the HRV test was a Heart math Certified Practitioner.

Data Analysis

With the assistance from Mike Atkinson, Research Manager from Heart math Institute, Descriptive characteristics and Pearson correlation analysis between HRV measures (IBI, SDNN, RMSSD, MHRR, normalized coherence, Total power, Very low frequency, Low frequency and High frequency power along with the Low frequency/High frequency ratio), POQA and PSS scales were performed using the SPSS Version 22.0. The significance level for correlations was set at alpha of .05. To correct for skewness, HRV frequency domain measures and RMSSD were natural log transformed prior to performing the correlation analysis.

Demographic Characteristics

A total of 87 people signed the consent forms to participate, of which 2 were excluded due to technical artefacts in the dataset related to the one-minute of six deep-breath cycles protocol. This resulted in 85 participants who completed the HRV measurements, POQA and PSS questionnaires. Frequency tables for the demographic characteristics are presented in Figure 1 to Figure 9, while descriptive statistics related to the research are presented in Table 1 and Table 2. The majority of the subjects were female (61.1%) and 38.8% were male. Most of the subjects were within the age 31-40 (47%). 43.5 % were within the age 21-30, and 8.2% were within the age 41-50. Only 1 subject was more than 50 years old and no subjects were under age 21.

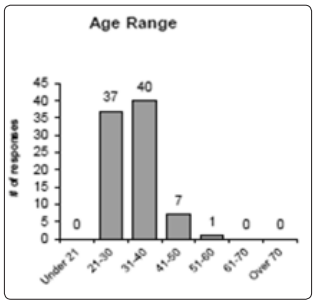

Figure 1: Age Range of participants as reported from POQA-R4

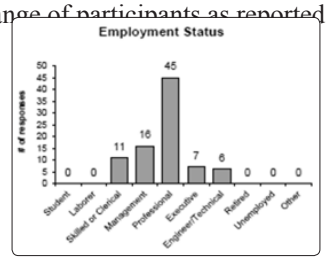

Figure 2: Employment Status of participants as reported from POQA-R4

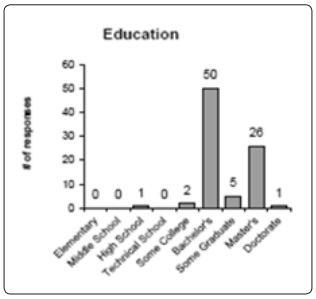

Figure 3: Education Levels of participants as reported from POQA-R4

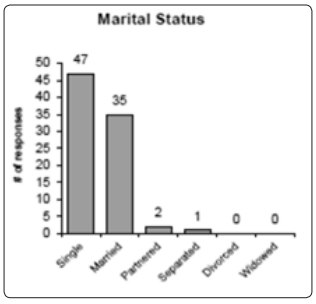

Figure 4: Marital Status of participants as reported from POQA-R4

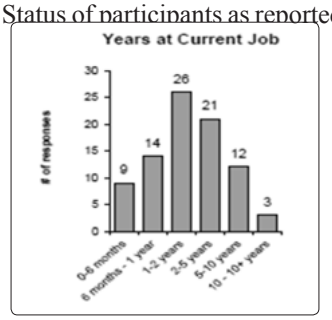

Figure 5: Years at Current Job of participants as reported from POQA-R4

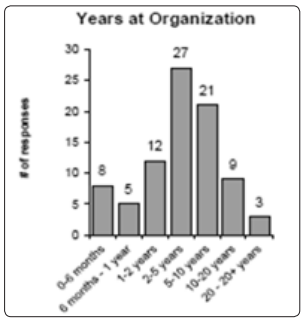

Figure 6: Years at Organization of participants as reported from POQA-R4

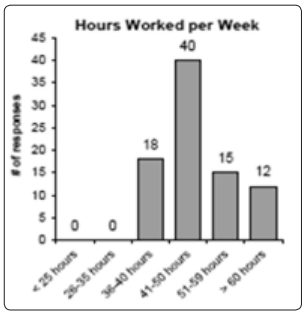

Figure 7: Hours Worked per Week of participants as reported from POQA-R4

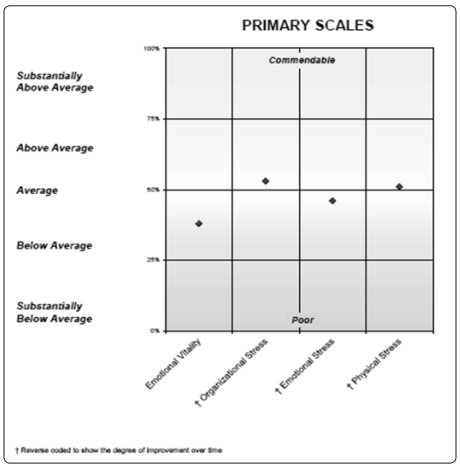

Figure 8: Organizational Scores as compared to norms from a large sample of 5071 employees as reported from the POQA-R4

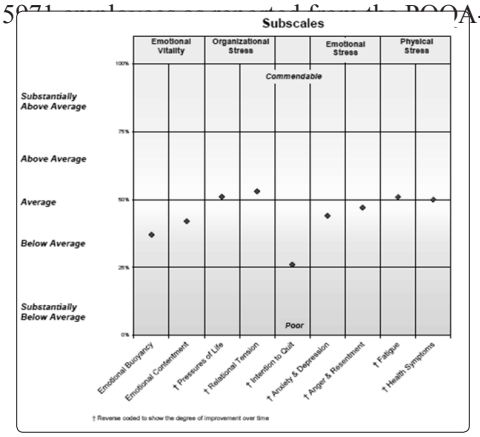

Figure 9: Associated Subscales as reported from the POQA-R4

Figure 10: emWave Pro Plus Computer Hardware and HRV Monitor Reading (Institute of HeartMath, 2016

Table 1

Descriptive Statistics					
	Male	**Female**			
Gender, n	33	52			
	N	Mean	SD	Min	Max
Age, y	85	32.65	6.10	23	54
1-Minute HRV Deep Breathing Assessment					
Mean Heart Rate, BPM	85	70.37	8.67	53	99.5
Mean Inter-beat interval, ms	85	874.92	104.47	623.7	1142.8
Mean Heart Rate Range, BPM	85	20.73	8.11	6.6	43.8
SDNN, ms	85	87.73	26.88	41.8	165.7
Ln RSSD, ms	85	4.08	0.36	3.4	5
Normalized Coherence, %	85	79.17	10.81	48	92.9
5-Minute Resting HRV					
Mean Heart Rate, BPM	85	69.03	9.86	37.3	100.1
Mean Inter-beat interval, ms	85	891.35	138.80	603.6	1616
SDNN, ms	85	53.70	15.65	25.3	97.3
Ln RMSSD, ms	85	3.77	0.33	3	4.7
Ln Total power, ms^2 /Hz	85	6.54	0.73	4.8	7.8
Ln Very low frequency, ms^2 /Hz	85	5.45	0.88	3.4	7.2
Ln Low frequency, ms^2/Hz	85	5.11	0.97	2.7	7.3
Ln High frequency, ms^2/Hz	85	5.14	0.80	3	6.8
Ln Low frequency / High frequency ratio	85	-0.04	0.95	-2.3	2.3
Normalized Coherence, %	85	38.93	9.72	18.5	71
Perceived stress scale	85	17.69	5.70	4	36
Personal and Organizational Quality Assessment – Revised					
Emotional Vitality	85	4.13	0.89	2.2	6
Organizational Stress	85	4.30	1.00	1.8	6.2
Emotional Stress	85	2.76	0.81	1.2	5.5
Physical Stress	85	3.16	0.89	1.3	5.1
Emotional Buoyancy	85	4.17	1.01	2.1	6.3
Emotional Contentment	85	4.07	1.01	2.3	6
Pressures of Life	85	4.45	1.24	1.2	6.6
Relational Tension	85	4.21	1.24	1.3	7
Stress	75	8.40	3.33	1	14
Anxiety & Depression	85	2.92	0.98	1.3	6.3
Anger & Resentment	85	2.62	0.80	1.1	4.9
Fatigue	85	3.75	1.21	1.3	6.5
Health Symptoms	85	2.78	0.86	1.2	5

Intention to Quit																																
	85																															
	3.89																															
	1.66																															
	1																															
	7																															

Pearson Correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1. Age	-																															
1-Minute HRV Deep Breathing Assessment																																
2. Mean Heart Rate, BPM	-0.02	-																														
3. Mean Inter-beat interval, ms	0.01	-.983**	-																													
4. Mean Heart Rate Range, BPM	-0.18	.583**	-.533**	-																												
5. SDNN, ms	-.235*	-0.03	0.09	.723**	-																											
6. Ln RMSSD, ms	-0.20	-0.18	.240*	.623**	.885**	-																										
7. Normalized Coherence, %	0.05	0.07	-0.07	0.12	0.20	0.01	-																									
5-Minute Resting HRV																																
8. Mean Heart Rate, BPM	-0.01	.825**	-.814**	.433**	-0.15	-.250*	-0.06	-																								
9. Mean Inter-beat interval, ms	-0.03	-.751**	.777**	-.370**	0.19	.276*	0.07	-.956**	-																							
10. SDNN, ms	-.290**	-.326**	.358**	0.07	.423**	.439**	0.13	-.423**	.468**	-																						
11. Ln RMSSD, ms	-.395**	-.329**	.364**	0.14	.501**	.565**	0.09	-.453**	.496**	.781**	-																					
12. Ln Total power, ms^2/Hz	-.272*	-.273*	.294**	0.11	.405**	.429**	0.10	-.332**	.347**	.895**	.671**	-																				
13. Ln Very low frequency, ms^2/Hz	-.215*	-.357**	.377**	-0.13	0.16	.244*	-0.01	-.407**	.420**	.698**	.472**	.827**	-																			
14. Ln Low frequency, ms^2/Hz	-0.12	-0.09	0.12	0.19	.348**	.318**	0.08	-0.15	0.16	.744**	.526**	.831**	.536**	-																		
15. Ln High frequency, ms^2/Hz	-.402**	-.243*	.257*	0.20	.532**	.531**	0.16	-.323**	.330**	.736**	.835**	.664**	.394**	.465**	-																	
16. Ln Low frequency / high frequency ratio	0.21	0.10	-0.09	0.02	-0.10	-0.12	-0.07	0.12	-0.12	0.16	-0.16	.309**	.235*	.658**	-.357**	-																
17. Normalized Coherence, %	0.11	0.01	-0.03	0.02	0.11	0.04	0.07	-0.01	0.01	0.20	0.08	.284**	-0.02	.326**	.265*	0.10	-															
18. **Preceived stress scale**	0.03	0.18	-0.19	0.17	0.02	0.01	0.09	0.18	-.217*	-.255*	-.282**	-0.18	-0.13	-0.08	-0.19	0.07	-0.03	-														
Personal and Organizational Quality Assessment - Revised																																
19. Emotional Vitality	0.12	0.06	-0.03	-0.06	-0.14	-0.10	-0.07	0.07	-0.03	0.00	-0.03	-0.06	-0.07	-0.07	-0.05	-0.04	0.11	-.479**	-													
20. Organizational Stress	0.07	-0.15	0.16	-0.02	0.10	0.11	-0.01	-0.16	0.14	0.05	0.03	0.06	0.15	0.01	0.05	-0.04	-0.04	.411**	-.358**	-												
21. Emotional Stress	-0.08	0.12	-0.12	.216*	0.06	0.13	0.03	0.04	-0.07	0.03	0.05	0.08	0.10	0.11	0.03	0.08	-0.09	.723**	-.484**	.422**	-											
22. Physical Stress	-0.04	0.16	-0.17	0.17	0.03	0.06	0.20	0.05	-0.06	0.03	0.00	0.06	0.10	-0.01	0.08	-0.08	-0.03	.394**	-0.17	.382**	.561**	-										
23. Emotional Buoyancy	0.20	0.02	-0.01	-0.02	-0.08	-0.03	-0.06	0.08	-0.05	0.00	-0.05	-0.06	-0.09	-0.04	-0.05	-0.02	0.16	-.427**	.919**	-.314**	-.428**	-0.15	-									
24. Emotional Contentment	-0.02	0.08	-0.05	-0.10	-0.18	-0.16	-0.06	0.03	0.02	0.01	0.01	-0.03	-0.01	-0.07	-0.03	-0.06	0.03	-.428**	.836**	-.315**	-.435**	-0.17	.553**	-								
25. Pressures of Life	-0.02	-0.16	0.18	-0.07	0.05	0.06	0.11	-0.18	0.17	0.07	0.07	0.05	0.16	-0.02	0.10	-0.11	-0.13	.381**	-.344**	.899**	.430**	.400**	-.339**	-.252*	-							
26. Relational Tension	0.14	-0.07	0.08	0.04	0.12	0.10	-.222*	-0.05	0.04	-0.02	-0.05	0.04	0.04	0.03	-0.02	0.05	0.13	0.21	-0.18	.725**	0.15	0.12	-0.12	-0.20	.393**	-						
27. Stress	0.17	-0.04	0.03	0.04	0.07	0.12	0.02	-0.10	0.05	0.03	-0.02	0.02	0.08	0.02	-0.04	0.07	-0.03	.378**	-.266*	.430**	.395**	.320**	-0.18	-.318**	.240*	0.19	-					
28. Anxiety & Depression	-0.15	0.13	-0.13	0.19	0.05	0.12	-0.01	0.06	-0.09	0.06	0.09	0.09	0.10	0.07	0.06	0.03	-0.11	.669**	-.517**	.406**	.918**	.514**	-.489**	-.417**	.406**	0.14	.429**	-				
29. Anger & Resentment	0.01	0.08	-0.08	0.20	0.05	0.12	0.06	0.02	-0.04	-0.01	-0.01	0.06	0.07	0.13	-0.01	0.13	-0.05	.649**	-.360**	.362**	.905**	.509**	-.285**	-.374**	.377**	0.14	.278*	.661**	-			
30. Fatigue	-0.07	0.18	-0.18	0.20	0.05	0.08	0.14	0.04	-0.05	0.00	0.03	0.02	0.07	-0.03	0.08	-0.10	-0.03	.428**	-0.17	.458**	.606**	.883**	-0.13	-0.18	.464**	0.18	.367**	.580**	.524**	-		
31. Health Symptoms	0.00	0.11	-0.13	0.11	-0.01	0.02	0.21	0.05	-0.06	0.05	-0.03	0.08	0.10	-0.01	0.06	-0.06	-0.02	.287**	-0.15	.229*	.406**	.902**	-0.15	-0.12	.254*	0.04	0.21	.354**	.387**	.594**	-	
32. Intention to Quit	-0.06	-0.13	0.12	-0.09	0.04	0.08	0.07	-0.15	0.12	0.12	0.15	0.19	.234*	0.10	0.13	0.00	0.04	.400**	-.389**	.557**	.444**	.288**	-.436**	-0.21	.536**	.325**	.284*	.455**	.350**	.335**	0.19	-

Correlation, significance (2-tailed). * $p < 0.05$, ** $p < 0.01$

The majority of participants reported working between 41-50 hours per week (47%); 21% of participants reported working between 36-40 hours per week; 17.6% working 51-59 hours per week and 14% reported working more than 60 hours.

Quantitative Data Results

HRV and Subjective Stress

Three significant negative correlations were found between Subjective Stress and HRV measures: (1) Perceived Stress and 5-minute Mean Inter-Beat-Interval (IBI), r = -0.217*; (2) Perceived stress and 5min SDNN, r = -0.255* and (3) Perceived stress and Ln 5min RMSSD, r = -0.282**.

HRV and Age

Significant negative correlations were found between age and the HRV measures; 1-minute SDNN (r = -.235, $p < 0.01$), 5-minute SDNN (r = -.290, $p < 0.01$), 5-minute RMSSD (r = -.395, $p < 0.01$), Total Power (r = -.272, $p < 0.05$), Very Low Frequency (r = -.215, $p < 0.05$) and High Frequency (r = -.402, $p < 0.01$). There are more significant relationships between the HRV measurements during the 5-minute resting period than with the 1-minute Deep Breathing Assessment.

HRV and Emotional Stress

First of all, a significant positive correlation was found between Emotional Stress and the Mean Heart Rate Range (MHRR), r = 0.216*.

HRV and Relational Tension

A significant negative correlation was found between Normalized Coherence and Relational Tension (r = -.222, $p < 0.05$).

Very Low Frequency (VLF) and Intention to Quit

A significant positive correlation was found between Intention to Quit and 5-minute Ln Very Low Frequency (VLF), r = 0.234*.

PSS and POQA-R4

The PSS and POQA-R4 were strongly correlated, except for Relational Tension.

A Summary of Results

This chapter presented descriptive statistics and quantitative correlational results between HRV (Objective Stress), PSS and POQA-R4 (Subjective Self-Reported Stress) that attempted to answer the following research questions.

Research Question 1

In what way can HRV be used to accurately measure the effects of workplace stress in Hong Kong?

HO: There is no (statistically significant) relationship between HRV and Workplace Subjective Stress (H0: r=0). H1: There is a (statistically significant) relationship between HRV and Workplace Subjective Stress (H1: r<>0). Since there were three significant negative relationships between perceived stress scale (short term stress) and HRV; Perceived stress and 5min IBI, r= -0.217*, Perceived stress and 5min SDNN, r= -0.255* and Perceived stress Ln 5min RMSSD, r= -0.282**, H0 would be rejected. This indicates that overall HRV is significantly correlated with short-term perceived workplace stress.

Research Question 2

What are the effects of workplace stress in Hong Kong on HRV?

A negative relationship between short-term perceived stress and HRV means that the lower the short term perceived stress, the higher the overall HRV the person is capable of producing. Moreover, a significant positive correlation was found between Emotional Stress and the Mean Heart Rate Range (MHRR), r = 0.216*, which indicates that the higher the emotional stress an employee faces, the higher his or her HRV.

Research Question 3

In what way does HRV compare with self-reports of stress in Hong Kong?

The participants self-report results on the POQA revealed the stressors and after effects of employee stress. Comparing the four primary scales of the organizational scores to norms from a large convenience sample of 5971 working adults, Figure 8 shows that out of the four primary scales: emotional vitality, organizational stress, emotional stress and physical stress, with emotional vitality and emotional stress within the Below Average range. From the correlational analysis, it was reported that a significant positive correlation was found between Emotional Stress and the Mean Heart Rate Range (MHRR), r = 0.216*, which indicates that the higher the emotional stress an employee faces, the higher his or her HRV. Moreover, from the associated subscales in Figure 9, out of the nine subscales, Emotional Buoyancy, Emotional Contentment, Intention to Quit, Anxiety & Depression, and Anger & Resentment were within the Below Average range. A significant positive correlation was found between Intention to Quit and 5 minute Ln Very Low Frequency (VLF), r = 0.234* which indicates that healthier employees may have higher intentions of quitting their jobs.

Research Question 4

What is the overall level of comfort a typical Hong Kong employee experiences?

A significant negative correlation was found between age and the HRV measures; 1 minute SDNN ($r = -.235$, $p < 0.01$), 5 minute SDNN ($r = -.290$, $p < 0.01$), 5 minute RMSSD ($r = -.395$, $p < 0.01$), Total Power ($r = -.272$, $p < 0.05$), Very Low Frequency ($r = -.215$, $p < 0.05$) and High Frequency ($r = -.402$, $p < 0.01$). This indicates that the older the employee, the lesser his or her overall HRV. A significant negative correlation was also found between Relational Tension and Normalized Coherence ($r = -.222$, $p < 0.05$), which may indicate that the healthier an employee, the lesser the relational tension. The mean PSS score is 17.69 where 13 is considered average while 20 or above is considered High Stress. On the other hand, the mean overall stress score in the POQA is 8.4 where 0 is the lowest (Most Calm) and 14 is the highest (Most Stressed). Moreover, from the descriptions in Research Question 3, out of the four primary scales: emotional vitality, organizational stress, emotional stress and physical stress, both emotional vitality and emotional stress are within the Below Average range while the rest of the scales are in the average range.

A Discussion on the Findings

Research Question 1

In order for the researcher to test the hypothesis as to whether HRV can be used to accurately measure workplace stress in Hong Kong, the researcher has cited how both subjective and objective aspects are required to measure workplace stress as they are interrelated [14-16]. It was of the researcher's interest to investigate how well the POQA and PSS correspond with HRV, an objective measure, which can reflect the balance between an employee's individual resources and demands of the workplace environment. Both HRV and PSS were described to be a strong independent predictor of future health as well as indicators of workplace stress [35,19]. In this study, it was hypothesized that POQA and PSS would have a negative correlation with HRV.

In line with the findings of previous studies, there were more significant relationships between the HRV measures and PSS than with the POQA. Most historical workplace stress research that correlates HRV with workplace stress shows a negative correlation between the variables. For instance, the results are consistent with those of Da Silva when they assessed the correlation between PSS and HRV parameters and reported that the increase in perceived stress is correlated to lower heart rate variability in healthy young subjects [25]. Moreover, Da Silva et al analyzed data from 35 healthy young volunteers and found a significant correlation between Perceived stress and Low Frequency-LF (ms2) by frequency domain HRV analysis. Probably due to the smaller number of subjects, other global variables such as Total Power and SSDN had also negative coefficients, but did not have any significant correlation with PSS-14, yet this study contributed to the literature three additional significant negative correlations between PSS and HRV, with (1) Perceived Stress and 5 minute Mean Inter-Beat-Interval (IBI); (2) Perceived stress and 5min SDNN, and (3) Perceived stress and Ln 5min RMSSD.

Similarly, Fohr found that subjective self-reported stress has been associated with the objective physiological stress which is consistent with the result of this research [36]. Hence, Fohr et al suggested that the objective stress assessment such as HRV provides an additional aspect to the evaluation of stress.

Research Question 2

It was surprising to see a significant positive correlation between Emotional Stress and the Mean Heart Rate Range (MHRR), which indicates that the higher the emotional stress an employee faces, the higher his or her HRV. At first glance, it seems counter-intuitive; however, the researcher offers four perspectives to explain this surprising finding.

Personality

According to Turiano, it appears that an employee can be a "healthy neurotic." Turiano and his team concluded that the health anxiety that employees who are high in neuroticism or emotional stress may feel adaptive when it is accompanied by high conscientiousness [37]. In other words, neuroticism or emotional stress may lead the person to worry but conscientiousness leads the person to be self-disciplined and to take action when one's behavior veers into the unhealthy range. The unhealthy neurotics are the ones whose low conscientiousness means that they have fewer healthy coping mechanisms. Turiano et al further pointed out that when employees were stressed and unhappy, they might turn to overeating, drinking, and smoking. Nevertheless, they said that it was possible that other known health culprits could play a role such as lack of sleep, or even a relationship conflict.

Asian Culture

Numerous research studies have established that using emotion

suppression, whether routinely or experimentally-induced, is associated with the unhealthy well-being [38]. Moreover, emotion suppression eliminates the experience of positive emotions while enhancing the experience of negative emotions. Contrary to western cultures, the Asian culture tends to mask negative emotions which are deemed as signs of maturity and awareness. In addition, their reluctance to express negative emotions has potential negative relational concerns which threaten group harmony. This may provide insights to the current research which holds the view that unhealthy Asian employees tend to suppress their emotions and that the suppressed emotions are not regulated successfully.

Emotion Regulation

Emotion regulation involves the process by which people manage both negative and positive emotions. Furthermore, successful emotion regulation, by either reappraisal or suppression, has been shown to lead to increased vagally mediated HRV [39]. Fujimura and Okanoya therefore suggest that healthier employees (in this research study) are able to better regulate their emotional stress as compared to the unhealthier ones because participants with a high baseline of vagally mediated HRV may be spontaneously using emotion regulation strategies more often during an emotional conversation than participants with a low baseline of vagally mediated HRV.

Age Factor

As the majority of the participants in this research were between the age of 21 and 40 (considered as a young population group), according to R. McCraty, these participants are possibly still physiologically resilient and as the amount of HRV reflects long-term processes, emotional stress traits would not show up until later in life, reflecting a depletion of the wear and tear on the ANS [40].

Research Question 3

From the POQA, the low score of emotional vitality indicates low scores on both Emotional Buoyancy and Emotional Contentment Subscales. A low score on the Emotional Buoyancy subscale indicates that it is likely that the employees feel that they have low levels of emotional energy available for investment in their work and personal lives. A low score on the Emotional Contentment subscale suggests that the employees may be feeling only low levels of contentment and inner peace with their lives, both at work and off the job.

On the same side of the coin, the low score of emotional stress as shown in Figure 8 indicates low scores on both the Anxiety/Depression and the Anger/Resentment subscale (Figure 9). When looking at the normative summary scales which are reverse coded, low scores on the Anxiety/Depression subscale indicate that a notable proportion of employees may be experiencing high levels of anxiety, unhappiness, sadness, and/or depression. Low scores on the Anger/Resentment subscale indicate that a notable proportion of employees may be experiencing high levels of anger and resentment and may experience difficulty in controlling their feelings and emotions. Hence, from the correlational analysis, it was reported that a significant positive correlation was found between Emotional Stress and Mean Heart Rate Range (MHRR), which indicates that the higher the emotional stress an employee faces, the higher his or her HRV. Discussions on this were noted in Research Question 2.

Intention to quit

The poor score on this subscale in the POQA indicates that there is an increased likelihood of a notable proportion of employees who are feeling sufficiently dissatisfied with their work environment and that they are thinking about leaving the organization (i.e., quitting their jobs). Yet another surprising finding from the research is that a significant positive correlation between Intention to Quit and 5 minute Ln Very Low Frequency (VLF) which indicates that healthier employees may have higher intentions of quitting their jobs. From the literature review, a Very Low Frequency (VLF) peak, ranging between 0.0033 and 0.04 Hz, is associated with an increased risk of adverse effects, and the VLF has stronger correlations with "all-cause mortality" than HF and LF power. According to McCraty & Shaffer, a lower VLF is the most predictive of future health problems, since a low VLF power is associated with arrhythmic death and posttraumatic stress disorder. Furthermore, the low power in VLF is associated with high inflammation and has been correlated with low levels of testosterone [19].

Trying to make sense that healthier employees have an intention to quit, according to Porges, from a polyvagal perspective, when an employee is in a situation that resembles a life-threatening situation, he or she may be unable to utilize mobilization strategies (quitting their jobs) or use social engagement strategies (relating to other colleagues) to get out of the situation [41]. Additionally, the "neuroception" features of that challenge may cause that employee to experience a shutdown condition, which is characterized by the old unmyelinated vagus and coupled with reduced blood flow, especially blood flow to the brain and exhibiting dissociative features. Porges further stated that the greater issue is not the traumatic experience at the workplace, but the making sense of the physiological response that the traumatic event has triggered. In other words, it is not just about the bad event but the consequences of that event on the employees' physiology and on their nervous systems that is profoundly changing their ability to adapt in the workplace. This may well explain why employees who are not having intentions to quit are what Porges has coined as "immobilized with (or without) fear".

Research Question 4

In line with previous research findings, significant findings between age and the HRV measures indicate that the older the employee, the lesser his or her overall HRV [32]. It is surprising however that the MHRR in the 1 min deep breathing assessment was not as significantly related to age, especially as age was highly correlated with the SDNN and RMSSD in the 5 minute resting HRV assessment. A possible explanation for this is that the 1 min deep breathing assessment is a challenge test that is getting at how much overall HRV the participants' system is capable of producing at that time. Having that in mind, the majority of the participants in this research were between the age of 21 and 40 (considered as a young population group), which possibly explains why the age correlations in the 1 min assessments were not stronger if the age range was not wide enough [40].

Relational Tension

A significant negative correlation was also found between Relational Tension and Normalized Coherence, which may indicate that the healthier an employee, the lesser the relational tension. According to R. McCraty, relational tension is clearly a source of stress, and he suggests that it is one of the most harmful types of stress. When there is a lower coherence in the 1-min test, especially if the amount of HRV is within the normal range (MHHR, and SDNN), he suspects that it indicates an issue with the coupling of the respiratory and

the cardiovascular systems within the brainstem. He postulates that this will eventually be shown to be an early warning indicator and is associated with future health challenges [42].

Furhermore, R. McCraty states that relational tension due to lack of coupling and alignment with others may be reflected in lower coupling of the respiratory and cardiovascular systems [40]. He describes how HRV synchronization between mothers and young children nourishes a biological synchronized rhythm which provides the foundation for a social rhythm for the child. Hence, the development of one's internal biological oscillators is critical to future social connection and self-regulation.

Where relational tension is concerned, Porges suggests that "toxic load" should be understood from the psychological and physiological standpoint such as bodily cues [41]. A healthy employee needs to feel "safe" not just physically but "as an emotion, mood or affective state" as well. Porges postulates that physiologically, it is of paramount importance to feel safety such as how the employee's nervous system desires to feel safe. A decrease in relational tension can be seen as having "effective social interactions" among colleagues, superiors and subordinates which "may actively dampen defense systems and, when defense is down-regulated…[employee's] physiological sate provides neural opportunities for [one] to learn and to form strong social bonds while simultaneously supporting health, growth and restoration", thus healthier employees [41]. Porges instigates the significance of social interactions in enabling employees to feel safe because an absence of compassionate face-to-face interactions among colleagues which include bodily cues and vocal cues with warm controlled voices triggers bodily state shifts which fuels the internal defenses and foster miscommunication and misunderstandings amongst colleagues such as "task instructions". Moreover, the researcher has observed how the increased use of technology in the workplace such as online chats dampens face-to-face interactions. Porges further describes how the Social Engagement system activates the Vagus nerve where for instance, having calm conversations will not only enhance connection with other colleagues but it triggers neural circuits in our bodies that calm the heart, relax the gut and turns off the fear response. The Vagus nerve is further described as having the ability to transmit messages quickly from the brain stem to the heart, lungs, and intestines. Moreover, the Vagus nerve regulates some facial muscles, including the ear, and can enhance our ability to give others appropriate facial cues and even hear others better. Hence, the Vagus nerve influences the employee's heart rate and breathing, and is involved in how an employee perceives, reacts and recovers from stress. When an employee feels confident in a social context, his or her heart rate and breathing slows down, the blood pressure drops with stress responses switching off. The body enters a state of physical calmness. Hence, an employee feels safe to move closer to another colleague, making intimacy possible. Therefore, social engagement can enhance our sense of safety, creating a positive feedback loop which leads to further calming. On the other hand, if the body detects that he or she (an employee) is in "danger", it switches to the fight/flight response, driven by the body's HPA (Hypothalamic-Pituitary-Adrenal) Axis, which changes into symptoms of anxiety in the workplace context.

Mean Score

The mean PSS score is 17.69 where 13 is considered average while 20 or above is considered High Stress. On the other hand, the mean overall stress score in the POQA is 8.4 where 0 is the lowest (Most Calm) and 14 is the highest (Most Stressed). In this study, the correlational analysis between PSS and POQA are significantly correlated, therefore, this suggests that the overall level of comfort an employee experiences is a level close to High Stress. Moreover, from the discussions in Research Question 3, out of the four primary scales: emotional vitality, organizational stress, emotional stress and physical stress, both emotional vitality and emotional stress are within the Below Average range, while the rest of the scales are in the average range. The poor score on the Intention to Quit subscale of POQA is the most surprising finding and is considered a red flag to management as it indicates that a notable proportion of employees are feeling sufficiently dissatisfied with their work environment that they are thinking about quitting their jobs.

Limitations and Delimitations

A limitation of measurement bias might have occurred since the survey data was self-reported; results depended on the effort and honesty of each participant. Participants in the study might have been reluctant to give socially unacceptable answers in the questionnaires, for fear of being judged or are not self-aware enough to provide accurate responses. This might skew the results and caused errors in the correlational analysis. Since the research was on workplace stress, another limitation of surrogate information error might have occurred because the stress the employees experienced might have been non-workplace related such as family bereavement and loss, relationship breakdown, financial problems, family illnesses, commuting pressures, etc. It was also observed that the age range of the participants seemed to have skewed towards the younger population group of 21-40 and this might have led to a design bias limitation. Furthermore, participants that came from four lines of services within the corporation were not equally distributed – Department A (57.6%), Department B (11.7%), Department C (22.3%) and Department D (8.2%), which might have delineated a narrow demographic range of the corporation known as a measurement bias.

According to an article search, this was the first research conducted on the relationship between HRV, POQA and PSS in Hong Kong and using HRV as a potential physiological objective measurement for workplace stress. The sample size (n=85) of HRV measures was relatively large compared to other research studies and according to Clinical & Translational Science Institute (2017), the total sample size was of a significant level to achieve a power of .80 and an estimated effect size of 30.

Implications for Office Work

The overall research stresses that an average employee experiences a close to high level of workplace stress on a regular basis and therefore presenting a universal threat to organizational costs and workplace performance. The research data has concluded that emotional stress and relational tension are inherent in the workplace. Emotional stress may deplete one's internal resources regardless of whether one is healthy or non-healthy. Consequently, employee turnover may occur when employees are dissatisfied with the workplace environment. Besides, existing employees who do not have any intention of quitting may be exhibiting immobilization with (or without) fear, leading to a drop in workplace performance. It is therefore very critical to find new and effective tools such as HRV assessments to measure and monitor stress as well as having effective interventions to reduce and prevent workplace stress.

Implications for individuals

During the research study, all participants received a 5 to 10 minutes of Quick Coherence therapy where they learned skills of heart-focused breathing to respond to their perceived stress. This technique is simple, discrete, portable, fast and effective which makes it applicable at the workplace and elsewhere. Implications for organizations it is recommended that organizations ought to implement organizational resilient strategies such as Mindfulness Psychology as an integral part of a strategic framework of change management initiatives. The act of being mindful for employees and leaders within an organization means to be aware in the present moment, intention in thought and purposeful in action. Additionally, beneficial outcomes for the overall organization include competitive advantages, employee engagement, and decreased attrition, increased productivity, better wellbeing, and leadership development, better collaboration leading to healthier organizational culture, climate, longevity and social coherence.

Implications for OD

The outcome of this research provides OD a possibility to inculcate a culture of open-mindedness and to explore new concepts rooted in quantum physics and stress. Secondly, this research provides OD with an opportunity to develop new theories, skills and tools to pioneer the next generation of OD scholar-practitioners, adding to the body of knowledge as well as ensuring the longevity of OD. For instance, employees are more than a brain and a body but are constantly surrounded by a measurable human energy biofield that impacts individuals on emotional, physical, psychological levels as well as the people around them.

Recommendations for Further Research

A purpose of having future research is to align the various researches with the social and global Coherence notion propelled by the Heart math Institute. Future research will continue to address topics ranging from stress to reducing violence, reducing health costs, emotional regulation, biofeedback interventions, stress management and even other non-workplace topics such as the academic performance of children of different ages, PTSD, intuition, and much more. Hence, further research on the effects of employee stress and HRV needs to be conducted. The researcher has several suggestions for future research.

Repeat research

Similar research can be conducted in other Asian countries such as Singapore, Taiwan with a more diversified age group. A second way is to repeat the research with other subjective perceived stress surveys. Heart-brain and face-heart connections. Integrating the works of McCraty and Porges, comparable studies on heart-brain and face-heart connections can be further explored to add to the current body of knowledge regarding relational tension and resilience [40,41].

HRV research

Future research studies could use HRV stress measurements to evaluate the effectiveness of stress management interventions. Based on the findings, organizations can objectively identify the most effective intervention types and customize an employee assistance program to reduce workplace stress. Another study could include repeating the original research with additional primary biomarkers which can serve as confirmatory approaches.

Conclusion

This research has explored the correlation between a new quantitative stress measurement known as the emWave Pro Plus and compared it with two other sets of quantitative self-reported perceived stress data: the Personal and Organizational Quality Assessment (POQA) from Heart math and the Perceived Stress Scale (PSS) [28,8]. This research has looked at the effects of Hong Kong Employees' Workplace Stress on Heart Rate Variability (HRV).

Results from the study show that three significant negative correlations were found between Subjective Stress and HRV measures: (1) Perceived Stress and 5 minute Mean Inter-Beat-Interval (IBI); (2) Perceived stress and 5min SDNN; and (3) Perceived stress and Ln 5min RMSSD. It has been shown that HRV is an accurate objective measure for the short-term perceived workplace stress.

Three surprising findings have been found in the research in terms of Emotional Stress, Intention to Quit and Relational Tension. Firstly, a significant positive correlation has been found between the Emotional Stress and the Mean Heart Rate Range (MHRR), which indicates that the higher the emotional stress an employee faces, the higher his or her HRV. Secondly, a significant positive correlation has been found between Intention to Quit and 5 minute Ln Very Low Frequency (VLF), which indicates that healthier employees may have higher intentions of quitting their jobs. Thirdly, a significant negative correlation has been found between Relational Tension and Normalized Coherence, which may indicate that the healthier an employee, the lesser the relational tension. Discussions have been held to explain these surprising findings in order to make sense of the data. The research shows promising results and future studies should continue to tap into HRV as an objective measure of mental health and workplace stress.

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