PAPER • OPEN ACCESS

Stress Analysis Among University Students Using Psychometric Scale and Heart Rate Variability Approach

To cite this article: A H M Sufian and M A M Kamal 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1051** 012013

IOP Conf. Series: Materials Science and Engineering 1051 (2021) 012013 doi:10.1088/1757-899X/1051/1/012013

Stress Analysis Among University Students Using Psychometric Scale and Heart Rate Variability Approach

M Sufian A H[1] and M Kamal M A[2]

Bio-inspired System and Technology (Bio-iST) iKohza,
Malaysia-Japan International Institute of Technology (MJIIT),
Universiti Teknologi Malaysia, Wilayah Persekutuan Kuala Lumpur, MALAYSIA

[*] Corresponding author: msufianahamid@gmail.com

Abstract. Stress has become one of the major mental health problems in Malaysia. Most Malaysians underestimate and neglect this critical issue, not knowing what the consequences might be due to the lack of knowledge on stress analysis. Many researchers are trying to identify the causes and ways to overcome stress. With the help of advancing electronic systems engineering, primed heart rate biomarker has been earmarked as the tool to analyse stress. However, the relationship between heart rate variability approach and the quantification of stress is still an open research challenge. Therefore, the goal of this study is to explore the role of heart rate variability (HRV) and psychometric scale on stress and resilience analysis among university students and the effectiveness of interventions and Heart Rate Variability devices on improving resilience. 30 students, 15 males and 15 females aged 23 to 24 years old were picked as the subjects for this experiment according to their stress and resilience scores obtained from two questionnaires, Brief Resilience Scale (BRS) and Depression Anxiety Stress Scale-21 (DASS21). Their heart rate variability was measured using HeartMath EmWave device to observe the changes of their heart rhythm when a stimulus and an intervention is given. The data acquired from HeartMath EmWave were analyzed using Kubios HRV software, where it provides more in-depth analysis regarding the subjects' heart rate during the experiment. According to the results, most of the subjects' heart rate becomes incoherent during the stimulus phase. However, their heart rate changes into a coherence state due to the effectiveness of slow breathing techniques as an intervention. It helps the subjects to become calmer and synchronize their autonomic nervous system (ANS) with their brain and heart. Therefore, choosing the right intervention is vital to get a coherent heart rate, thus train how our body responds to stressors. The results also provide fruitful insight relating to how a human reacts when they are facing something difficult in their lives and indicates that heart rate variability biofeedback is important to achieve human wellness and validate the quantification of resilience and stress. This study concludes that the heart rate variability device and measurement are effective and have a vital impact to create stress awareness.

1. Introduction

At the moment, Malaysia has become one of the leading countries in the number of people who are suffering from mental illness. In 2020, during the COVID-19 outbreak, most Malaysians are showing signs of having mental health illness. From this issue, it can be seen that some people are suffering from problems such as anxiety, personality disorder, and cardiovascular disease and finding it hard to control their emotions when they are going through difficult situations [1].

Having the ability to manage emotions effectively is vital to form positive well-being [2]. Human emotions can be influenced and affected by the variation of heartbeats. This finding proves that the Autonomic Nervous System, which is controlled by the Heart Rate Variability (HRV) can be trained to achieve human wellness [3]. However, despite its medically proven benefits, self therapeutically care is not popular and the relationship between stress and Heart Rate Variability is still indistinct. Due to the lack of knowledge on stress and HRV, the public is mainly unaware and do not have much care of their emotional health.

Therefore, this study aims to analyse quantification of stress and resilience by using the psychological responses of psychometric tools, HeartMath emWave device, and Kubios HRV software on university students. The investigation will further provide useful information on self-care motivation to become healthy well-being and validate the effectiveness of the Heart Rate Variability approach to stress analysis.

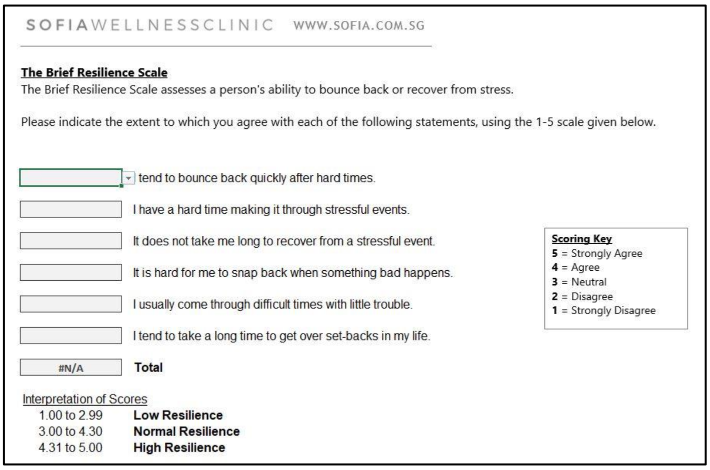
2. Methodology

3 ways of stress analysis were used for this study which are psychometric tools, HeartMath emWave device, and Kubios HRV software. The data collected from psychometric tools are unreliable because some of the students are biased when answering the questionnaires. Therefore, HeartMath emWave device was used to validate the data by tracing the subjects' pulses. Two experiments were being conducted. The subjects for experiment 1 went through 3 phases which are baseline, stimulus, and intervention while the subjects for experiment 2 went through baseline and intervention only. The purpose of implementing the stimulus phase in Experiment 1 is to trigger the subject's stress and analyse their level of resilience through heart coherence ratio. That is why subjects for experiment 2 did not go through the stimulus phase, as their level of stress was already known from the DASS-21 questionnaire. After that, the data obtained from HeartMath emWave were converted into XSL format, so that it can be accessible in Kubios HRV software. The data were further explored using multiple methods provided by this software.

2.1. Experiment 1 (Resilience)

2.1.1. Subjects

120 students from MJIIT UTM Kuala Lumpur were given the Brief Resilience Scale (BRS) each and their information were gathered. They were selected based on their scores obtained from BRS and divided according to their scores which are low, normal, and high resilience as shown in Figure 1.


SOFIAWELLNESSCLINIC WWW.SOFIA.COM.SG

The Brief Resilience Scale

The Brief Resilience Scale assesses a person's ability to bounce back or recover from stress.

Please indicate the extent to which you agree with each of the following statements, using the 1-5 scale given below.

I tend to bounce back quickly after hard times.

I have a hard time making it through stressful events.

It does not take me long to recover from a stressful event.

It is hard for me to snap back when something bad happens.

I usually come through difficult times with little trouble.

I tend to take a long time to get over set-backs in my life.

#N/A **Total**

Scoring Key
5 = Strongly Agree
4 = Agree
3 = Neutral
2 = Disagree
1 = Strongly Disagree

Interpretation of Scores

1.00 to 2.99	**Low Resilience**
3.00 to 4.30	**Normal Resilience**
4.31 to 5.00	**High Resilience**

Figure 1. Brief resilience scale

2.1.2. Brief Resilience Scale (BRS)

Based on the scale, participants were filtered out and the number of subjects that were chosen is around 30 students. These students are picked according to their scores obtained from the Brief Resilience Scale.

2.2. Experiment 2 (Stress)

2.2.1. Subjects

The subjects were chosen similarly to experiment 1. DASS-21 questionnaire was handed out to 120 MJIIT students and 30 students who got the highest score for each scale of stressor were asked to participate as the subjects. The students were also categorized into 3 groups of stressors which are depression, anxiety, and stress.

2.2.2. Depression, Anxiety, and Stress Scale - 21 Items (DASS-21)

As shown in Figure 2, Depression, Anxiety, and Stress Scale - 21 Items (DASS-21) is a set of questionnaires consists of three scales that are used to measure the emotional and mental condition of stress, depression, and anxiety. For the depression scale, it will assess whether the students' hopelessness and dysphoria. The score for anxiety scale will observe the skeletal muscle effect while the stress scale is to see the levels of chronic non-specific arousal. 30 students who obtained the highest score from DASS-21 will be asked to participate in our experiments.

DASS 21 SCORE

DEPRESSION SCORE	ANXIETY SCORE	STRESS SCORE

	Depression	Anxiety	Stress
Normal	0 - 4	0 - 3	0 - 7
Mild	5 - 6	4 - 5	8 - 9
Moderate	7 - 10	6 - 7	10 - 12
Severe	11 - 13	8 - 9	13 - 16
Extremely Severe	14 +	10 +	17 +

Figure 2. DASS-21 score interpretation

2.3. Session Flow

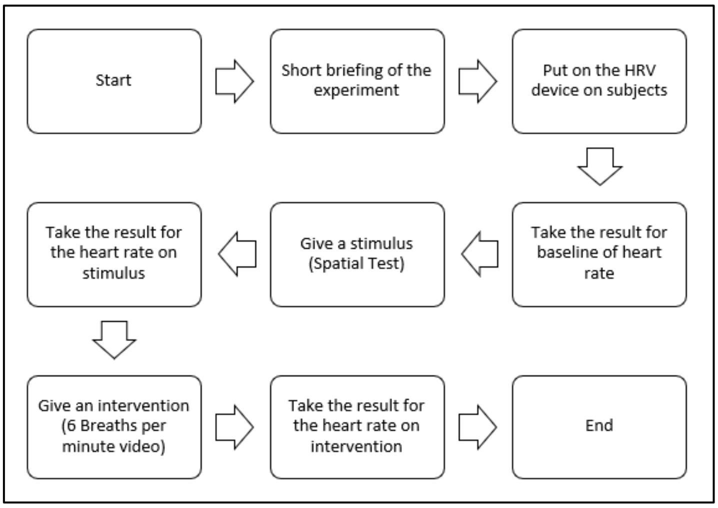


Figure 3. Session flow for experiment 1 (Resilience)

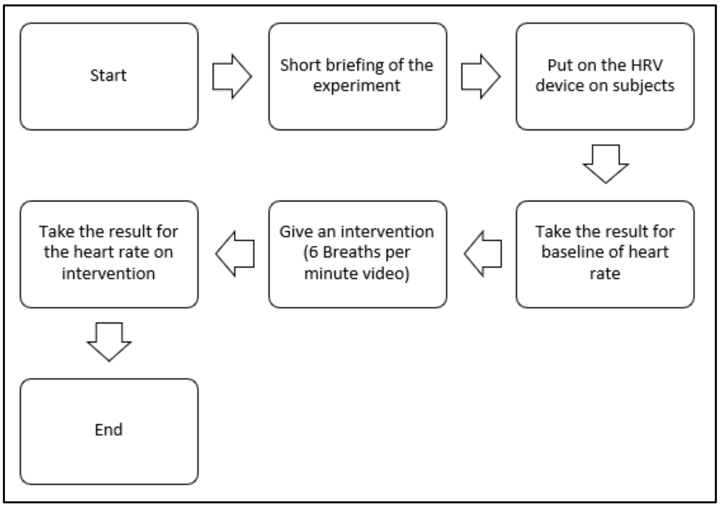


Figure 4. Session flow for experiment 2 (Stress)

Figures 3 and 4 show the flow of both experiments being conducted. Series of steps were taken to execute and obtain the data. Then, the data were analysed to see the full results of the experiment. Before going through the experiment, the subjects need to be healthy and did not take any medication to ensure that they are stress-free. The subjects signed a consent form and briefed about the session flow. The whole experiment was conducted in a room with air-conditioner to make sure that the subjects are comfortable to take the experiment. Subjects were instructed to relax and sit down while the HRV device is mounted to the subjects' ear lobe. Subjects were told to minimize their movement to prevent any noise from affecting the data collection. The data were collected by observing the changes in heart rate and coherence ratio.

2.4. Phases of Experiment

2.4.1. Baseline

To take the HRV readings of each participant, a five-minute baseline reference was allocated. For the next experiments of training, these readings will be the benchmark. A few things regarding the subjects must be checked such as their health to ensure that their stress level is not affected by anything before going through the experiment.

2.4.2. Stimulus

During the experiment, a spatial test was used as a stimulus because it will challenge the subjects to think and imagine how to manipulate 3D images and perceive patterns between them. The subjects were given five minutes to finish all the 10 questions of the spatial test. However, it is okay if they manage to finish it earlier.

2.4.3. Intervention

The subjects were given an intervention which is a video about the slow breathing technique. The students were instructed to inhale deeply for 5 seconds and exhale fully for 5 seconds. This will ensure that the students will breathe 6 breaths per minute which is the correct way to obtain optimum heart rate.

2.5. Hardware

2.5.1. HeartMath emWave Device

HeartMath emWave desktop Software Kit device was used as the biofeedback equipment in the experiment. It comes with a USB tool that was connected to the laptop or computer and a sensor. The sensor was put at the subjects' ear or finger to collect the subjects' pulse. The pulse collected will produce a waveform and the coherence ratio represents the subject's heart rhythm on the device and the data is in JSON format.

2.6. Software

2.6.1. Kubios HRV

The data from the HeartMath emWave device contains the Interbeat Intervals (IBI) value of the subject's heartbeat that can be used for the analysis of Kubios HRV software. However, the data must be converted into XSL format first. Some of the analysis in the software are Sympathetic and Parasympathetic Nervous System Index, nonlinear method, time, and frequency domain analysis. The time-domain analysis will show the result derived from the beat-to-beat RR intervals in time domain while frequency domain analysis will calculate the PSD estimate for the RR interval series.

3. Result and Discussion

3.1. Psychometric Scale

According to Figure 5, based on the results from the Brief Resilience Scale, the number of subjects who have high resilience is so low compared to the other score ranges. The subjects who are low resilient means that they are mentally vulnerable and might have a hard time bouncing back from certain situations that involving stress while high resilient subjects can control their emotions well. Normal resilience has the highest number of subjects. However, they tend to fall into other score ranges depend on their struggles. Anyone can learn and develop their resilience as it involves self-behaviour, actions, and thoughts. Therefore, the result of this experiment can show how their resilience can be built by going through the right intervention.

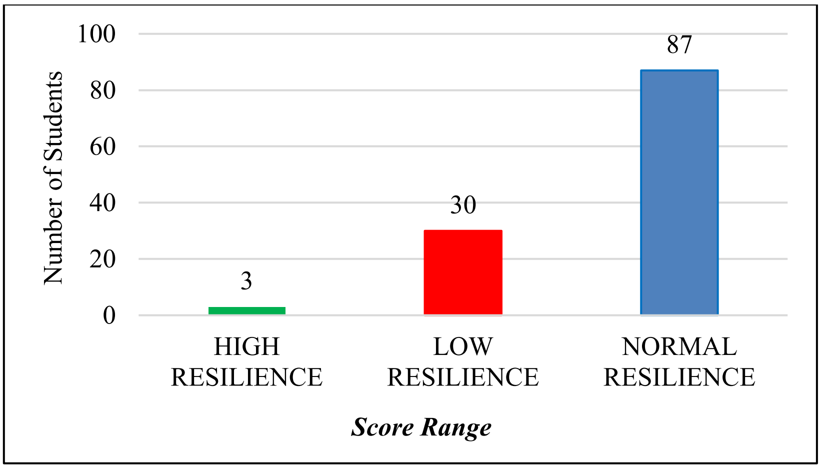


Figure 5. Result for the brief resilience scale

3.2. HeartMath emWave Device

3.2.1. Baseline

The emWave Pro software exhibits the variation of the heartbeats when the ear sensor is attached to the subject's earlobe. The coherence ratios are designed to show the level of stress of the subjects. The results obtained in this phase were used as the benchmark to compare the heart rhythm and coherence ratio score for the next phases. This result will provide the information needed to assess the condition of the Autonomic Nervous System (ANS).

3.2.2. Stimulus

When a stimulus is given, most of the subject's heart rhythm becomes incoherent. This proves that the desynchronization in the ANS occurred when the subject is going through something difficult or negative emotions. Based on Figure 6, the subject's heart rhythm is incoherent, and it is proved from the value of the coherence ratio.

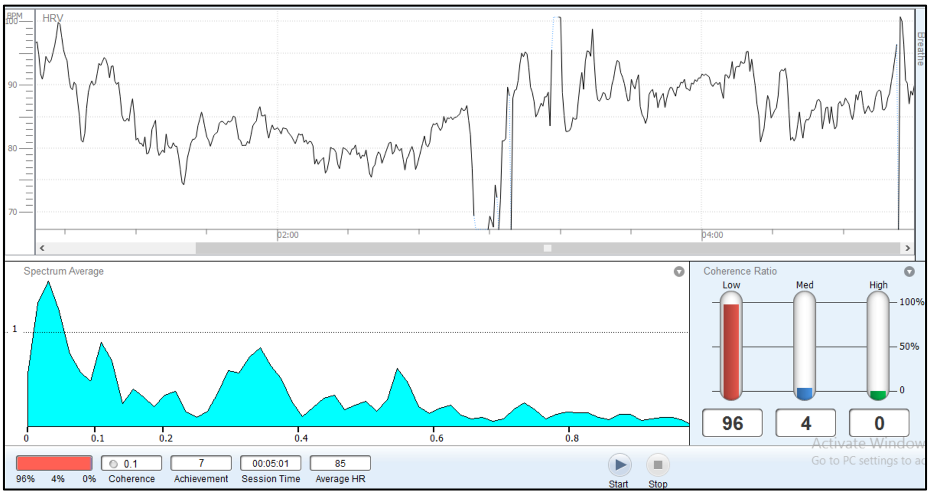


Figure 6. Result for incoherent heart rhythm when a stimulus is given

3.2.3. *Intervention*

Choosing the right intervention is vital to get a coherent heart rhythm. The coherence score changes from low to high due to the effectiveness of the slow breathing technique as the intervention. Figure 7 shows that during the intervention, a repetition of coherent sine-wave pattern waveform is produced which shows that the subject is experiencing a happier emotion which helps the subject to gain more control in the brain system and improve the synchronization between parasympathetic and sympathetic nervous system.

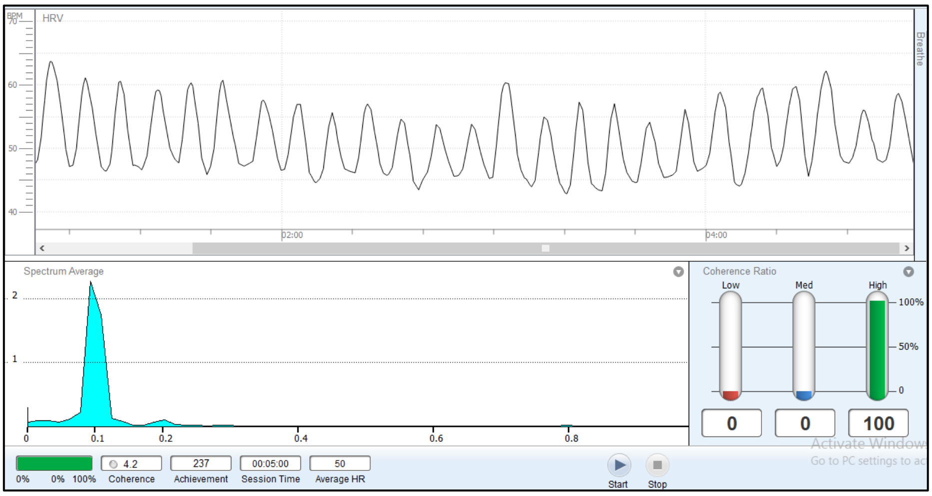


Figure 7. Result of coherent heart rhythm during the intervention phase

3.3. *Kubios HRV Software*

Multiple analyses can be used to such as Autonomic Nervous System Index, Time Domain Analysis, and Frequency Domain Analysis as shown in Figure 8. All of the analysis was used to further support the data obtained. During the experiment, the subject's response to the stimulus and intervention can be viewed based on the Autonomic Nervous System Index. The index value for the Parasympathetic Nervous System became higher when the stimulus is given, and it became lower during the intervention phase. For Time-Domain Analysis, the Interbeat Intervals (IBI) between each successful heartbeat were longer when the subjects are calm. This is because the Parasympathetic Nervous System prepares the body for 'rest and digest' activities. Frequency Domain Analysis was based on the Power Spectrum

Density from the HeartMath emWave device. The Frequency Domain Analysis was divided into 3 bands which are Very Low Frequency (VLF), Low Frequency (LF), and High Frequency (HF), and the values for all the bands range from 0.003 to 0.4 Hz.

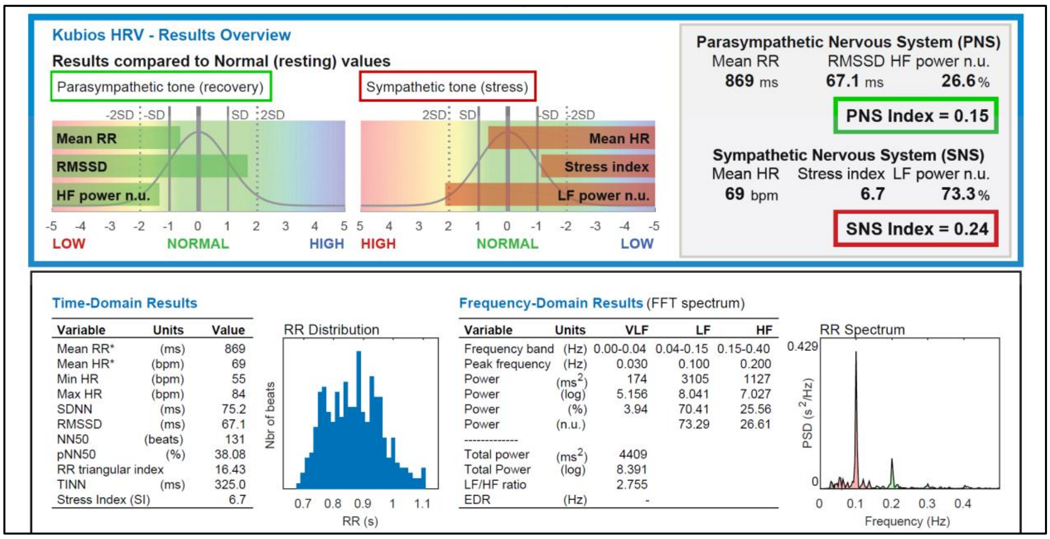


Figure 8. Kubios HRV analysis

3.4. Discussion

The emWave Pro software exhibits the variation of the heartbeats when the ear sensor is attached to the subject's earlobe. The coherence ratio of VLF, LF, and HF designate the level of stress of the subjects. The changes in heart rate in specific time frames will create waveforms with different frequencies. The level of coherence score can be categorized according to these frequency ranges, where high score is similar to high frequency (HF), medium score as low frequency (LF), and low score as very low frequency (VLF). A high coherence ratio of VLF indicates that the subject is stress while a high coherence ratio of HF says that the subject is calm.

With the help of HRV and the right interventions, we can acquire "resonant frequency" which is the pinnacle frequency for human being wellness. Slow breathing technique will teach the subjects to be in a calm mental state and stable emotions by breathing 6 times per minute. During the intervention, the Parasympathetic Nervous System will prepare our body to be calm and relax. Thus, it will produce a high amplitude peak in the LF region which is at around 0.1 Hz. Hence, it can be concluded that when an intervention is given to the subjects for five minutes, their stress level decreases which make the value of HF increases.

4. Conclusion

Ignorance of stress issues has led to the escalation in the number of people who are suffering from mental health. Researchers have gone through various scientific studies and experimentation to help ease this problem and up until this day, psychometric questionnaires have so far been the measurement for quantifying the level of stress. However, the results are underwhelming and inaccurate because of bias from the public when answering the questionnaires. Therefore, the invention of heart rate devices can help to prevent bias and validate the questionnaire results. Heart rate devices can also provide the ability needed to analyse and identify the causes of stress and ways to overcome it. Moreover, by utilizing the variations of heart rate, human emotions can be influenced using the right intervention, thus reduce stress and at the same time, improve resilience.

References

[1] Shanmugam H, Juhari JA, Nair P, Ken CS, Guan NC 2020 *Malaysian Journal of Psychiatry*

29(1)
[2] Ronen T, Hamama L, Rosenbaum M, Mishely-Yarlap A 2016 *Journal of Happiness Studies* **17(1)** 81-104
[3] Ferreira Jr M, Zanesco A 2016 *Motriz: Revista de Educação Física* **22(2)** 3-8
[4] McCraty R, Shaffer F 2015 *Global advances in health and medicine* **4(1)** 46-61
[5] Reiner R 2008 *Psychophysiology and Biofeedback* **33(1)** 55-61
[6] Sara JD, Prasad M, Eleid MF, Zhang M, Widmer RJ, Lerman A 2018 *Journal of the American Heart Association* **7(9)**
[7] MacLeod S, Musich S, Hawkins K, Alsgaard K, Wicker ER 2016 *Geriatric Nursing 3***7(4)** 266-272
[8] Mitchell MS, Greenbaum RL, Vogel RM, Mawritz MB, Keating DJ 2019 *Academy of Management Journal* **62(2)** 531-552
[9] Vesterinen V, Häkkinen K, Laine T, Hynynen E, Mikkola J, Nummela A 2016 *Scandinavian journal of medicine & science in sports* **26(8)** 885-893
[10] Perini R, Veicsteinas A 2003 *European journal of applied physiology* **90(3-4)** 317-325