ORIGINAL ARTICLE

Heart Rate Variability and Muscle Strength in Young Male Adults with Sedentary Behaviour

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ABSTRACT

INTRODUCTION: Sedentary behaviour or physical inactivity has been relatively prevalent among young adults globally. Multiple studies pointed out that Malaysia has been listed as one of the Asian countries with high prevalence of inactivity. Objective: This study aimed to examine the heart rate variability (HRV) and muscle strength among young adults with sedentary behaviour in order to explore the early impact of this behaviour on their physiological and physical health. **MATERIALS AND METHODS**: This cross-sectional study involved 185 healthy male adults aged 18-25 years. Participants' height and body compositions were measured and their level of physical activities were obtained using Short Questionnaire to Assess Health (SQuASH). Those with less than 150 minutes per week of physical activity engagement were classified as sedentary. Their HRV was analysed as a determinant for early physiological change that was influenced by the sedentary behaviour. Muscle strength of upper and lower body was assessed via handheld dynamometer to identify the physical fitness associated to the behaviour. **RESULTS**: Among the participants that volunteered in this study, approximately 44% were classified as sedentary. Analyses revealed that those with sedentary behaviour had lower variability of their HRV and lower muscle strength as compared to those who engaged with at least 150 minutes per week of physical activities. **CONCLUSION**: The highlighted evidence of the difference on parameters of HRV and muscle strength with this behaviour suggested that these were the suitable parameters to be utilised in determining subclinical improvement on health with any intervention to curb sedentary behaviour.

Keywords
cardiovascular, musculoskeletal, autonomic function, sedentary behaviour

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INTRODUCTION

Sedentary Behaviour Research Network (SBRN) proposes sedentary behaviour as any waking behaviour with an energy expenditure of ≤1.5 METs (metabolic equivalent of task), either in sitting or reclining posture.[1] Sedentary lifestyle has become a rising burden among South East Asia population including Malaysia. Studies in 2016 revealed that 60% adults in Malaysia aged 18-77 were physically inactive.[2] Studies have listed a wide range of contributing factors that could affect one's physical activity including age, race, ethnicity, education level and economic status.[2,3] The rise of sedentary lifestyle in the past decade has further increased the risk towards non-communicable diseases (NCD) in the population. The superior prevention strategies for non-communicable diseases has always been the involvement of physical activity in daily life. In order to promote those who are in sedentary behaviour to active lifestyle, wide range of activities have to be provided as choices.[4] However, there is lacking standardised parameters to be utilised to reflect the effect of various types of activities on health especially on subjects who are healthy at subclinical phase.

Heart rate variability (HRV) is a subclinical marker for heart problems that is widely used to characterise the functions of autonomic nervous system (ANS).[5] Heart rate fluctuates throughout the day following circadian rhythm, hence the HRV provides information on the integrity of cardiovascular system control. Besides, the parameter has also been described as an independent predictor of mortality in a

number of prospective epidemiological studies.[6] Interestingly, the assessment of HRV that is versatile and non-invasive suits to be done at any site without any restriction of clinical settings.

Another body system that is susceptible to be affected due to the sedentary behaviour is the musculoskeletal system.[7] Any regression of physical activities for 6 months will significantly reduce the integrity of muscle strength.[8] It is imperative to monitor the muscle integrity of upper and lower extremities in identifying the risk of disability, physical frailty and dependency that may occur at later life.[9] The aim of the study is to examine the differences of heart rate variability (HRV) and muscle strength in young adults with sedentary behaviour in order to identify the early impact of this behaviour on their physiological and physical health.

MATERIALS AND METHODS

Study sample

This cross-sectional study was carried out in 2018 among 150 healthy young male adults (18-35 years old). The sample size was attained using Cochran's formula.[10] Subjects were recruited from few institutions and community centres at Klang Valley and Negeri Sembilan, Malaysia. Since gender differences may result in different HRV reading, only male subjects are recruited in this study. Written consent was obtained from the subjects prior conducting the study. Respondents with metabolic syndrome, non-communicable or communicable diseases, musculoskeletal disorders, history of fall, history of motor vehicle accident (which can cause reduced muscle strength due to accidents) and known postural hypotension problem (to avoid subject from fainted during performing HRV test) were excluded from the study. The study protocol was reviewed and approved by the Universiti Sains Islam Malaysia Ethics Committee (USIM/ REC/0416-3). All tests were done in a close air-conditioned room with estimated room temperature of 24.0-26.5^{o}C.

Respondents' heights were measured using InBody BSM170/170B Stadiometer (Inbody, Seoul, Korea), whilst their weight and body composition was determined via InBody 270 Body Impedance Analyser (Inbody, Seoul, Korea). Classifications of physical activity were based on Short Questionnaire to Assess Health-Enhancing Physical Activity (*SQuASH*) as recommended by Juliana et al.[11] Respondents were requested to fill in the average duration (hours and minutes), intensity (low, moderate, high) and frequency of specific types of physical activity they were engaged in per week. Respondents who performed less than 150 minutes of moderate or 75 minutes of vigorous intensity of physical activity per week were categorised as sedentary.[12]

Heart rate variability measurement

Short-term HRV analysis was assessed using the Actiheart HRV monitoring device (CamNtech; UK). The Actiheart electrodes were attached to respondents' chests at the level of V4 and V5 (5th intercostal space) prior starting the test. The time and frequency domains were recorded. Respondents were instructed to perform Valsalva Manoeuvre (VM) in sitting position and Orthostatic Tolerance Test (OTT) in supine and standing position to stimulate both sympathetic and parasympathetic nervous systems. Prior starting each test, respondents were requested to rest for 10 minutes. The HRV was recorded starting from respondent's resting state until they completed all tests. They performed VM by exhaling into a mouthpiece fixed to a mercury manometer with standard sphygmomanometer tubing while subjects maintained a 40-mmHg column for 15 seconds. Blood pressure was measured in supine and standing positions after 15 minutes of rest using OMRON HEM-7120 Automatic Blood Pressure Monitor (Japan). OTT data was processed for 15 seconds during standing after being in supine position. Each respondent repeated the OTT three times and the mean was calculated. The results of postural mean blood pressure index (PMBPI) [(quick standing mean blood pressure – recumbent mean blood pressure)/ quick standing mean blood pressure X 100] were categorised into three: more than 0.05% as good, 0.05% to -18.0% as moderate and less than -18.0% as poor.[13] The HRV analyses were done using Actiheart 4 software that includes time and frequency domains.

Muscle strength measurement

JTech Commander Power Track MMT (JTech Medical; USA) was used to assess muscle strength and the force was recorded in Newton (N), measured to the nearest 0.1 N. The handheld dynamometer was used to measure force generated by groups of muscles involved. Respondents were requested to perform maximum isometric contraction during the dynamometry measurement. The dynamometer was placed perpendicular to subjects' tested limbs and all tests were done in supine position except for knee flexion and extension which were done in sitting position. The muscles that were tested include elbow flexors, elbow extensors, shoulder abductors, knee flexors, knee extensors, and hip abductors. The muscle strength tests were performed by a well-trained healthy examiner as the examiner must apply resistance to avoid movements of the tested limbs. One-minute gaps were given between two consecutive trials for each group of muscles. The highest force produced during each session was recorded as respondent's muscle strength. Test sequence started with assessment of the upper body followed by the lower body.

Data analysis

Normality tests were done. The normality test revealed that muscle strength variables were normally distributed and a parametric test could be used. However, distributions of some HRV variables significantly differed from the normal distribution and a non-parametric test was preferred. Hence, the differences between active and sedentary groups were examined using Mann Whitney U-Test for HRV variables and independent t-test for muscle strength. The significance was set at $p<0.05$. The data was analysed using the IBM Statistical Package for the Social Sciences version 24.0 software (USA).

RESULTS

There were 185 respondents volunteered in this study with the mean age of 21.3. Approximately 44.34% of the respondents were classified as sedentary. This study revealed that there was a significantly higher body mass index (BMI) and fat percentage among the sedentary group (Table I).

Table I Body composition profiles according to lifestyle preferences

Profiles	Active (n=103) Mean ± SD	Sedentary (n=82) Mean ± SD	*p* value
Anthropometry Profiles			
Age (years)	21.15 ±2.48	21.53 ±1.51	0.19
Height (cm)	168.3 ± 7.0	167.0 ± 7.2	0.15
Weight (kg)	68.0 ± 14.2	72.4 ± 19.9	0.13
BMI (kgm^{-2})	24.1 ± 4.9	25.9 ± 6.2	0.04*
Body Impedance Profiles			
Percent body fat (%)	20.5 ± 4.1	25.9 ± 10.0	0.001**
Skeletal muscle mass (kg)	29.0 ± 5.0	28.5 ± 5.8	0.51
Total body water (L)	37.8 ± 5.7	37.3 ± 7.1	0.60

HRV and muscle strength between active and sedentary groups

Results found that those who were sedentary had lower variability compared to those who were active (Table 2). Sedentary males showed a significantly lower mean rank in LF/HF during Valsalva manoeuvre ($p=0.003$). Results from the OTT revealed that the average maximum R-R values, average minimum R-R values, low frequency and high frequency were also lower in the sedentary group ($p\leq0.034$). Besides having a lower variability, sedentary males were also found to have significantly lower muscle strength for all groups of muscles than those who were active ($p \leq .029$).

Table II HRV and muscle strength according to lifestyle preferences

Profiles	Active (N=103) (median±IQR /mean±SD)	Sedentary (N=82) (median±IQR /mean±SD)	*p-value*
HRV			
Valsalva Manoeuvre			
Maximum R-R values (ms)	933 ± 147	937 ± 171	0.844
Minimum R-R values (ms)	675 ± 9	662 ± 91	0.458
Max/Min R-R values (ms)	1.4 ± 0.3	1.4 ± 0.3	0.486
standard deviation R-R values (SDNN) (ms)	75.7 ± 30.8	83.1 ± 40.2	0.340
Low Frequency (LF) (ms^2)	2054 ± 1874	2358 ± 1945	0.307
High Frequency (HF) (ms^2)	512 ± 702	1157 ± 1832	0.004*
Ratio LF/HF	8.0 ± 8.4	4.8 ± 4.3	0.010*
Orthostatic Tolerance Test			
Maximum R-R values (ms)	1145 ± 244	1072 ± 241	0.034*
Minimum R-R values (ms)	561 ± 75	556 ± 67	0.551
Max/Min R-R values (ms)	2.1 ± 0.6	1.9 ± 0.5	0.066
SDNN (ms)	122.5 ± 63.9	97.1 ± 42.0	0.001**
Low Frequency (ms^2)	3022 ± 9652	2096 ± 4546	0.177
High Frequency (ms^2)	1729 ± 5893	1037 ± 2715	0.174
Ratio LF/HF	2.9 ± 1.7	3.1 ± 2.0	0.729
Blood Pressure			
Postural mean blood pressure index (PMBPI) (mmHg)	8.0 ± 5.6	7.8 ± 6.9	0.909
Muscle strength			
Upper body strength (N)			
Elbow flexors	158.4 ± 34.7	133.4 ± 40.1	0.001**
Elbow extensors	139.7 ± 33.8	122.8 ± 30.2	0.001**
Shoulder abductors	148.1 ± 31.1	122.8 ± 29.8	0.001**
Lower body strength (N)			
Knee flexors	131.7 ± 37.4	114.3 ± 38.3	0.007*
Knee extensor	157.0 ± 42.7	141.0 ± 46.3	0.029*
Hip abductors	149.5 ± 32.9	133.9 ± 40.5	0.011*

N = Newton, LF=low frequency, HF=high frequency.
*significance value at $p < .05$ based on Mann-Whitney-U-test for HRV, and independent *t*-test for muscle strength
**significance value at $p < .001$ based on Mann-Whitney-U-test for HRV, and independent *t*-test for muscle strength

DISCUSSION

Sedentary behaviour is commonly defined as any waking behaviour characterised by an energy expenditure of ≤1.5 METS while being in a sitting or reclining posture.[1] This definition by the Sedentary Behaviour Research Network is based on the intensity of physical activity engaged together with the posture involved.[15,16] Tudor-Locke (2012) suggested that <5000 steps per day is an indicative measure that also can be used to define sedentary behaviour.[17] All these measures are validated and can be utilised interchangeably to define sedentary behaviour. Based on *SQuASH* questionnaire, discrimination between those who are active and sedentary can be easily done using the calculation of minute/week and activity score in the leisure time activity domain.[18]

South East Asia countries including Malaysia have been affected by the rising trend of physical inactivity and sedentary behaviour. The prevalence of 48.1% sedentary behaviour among males in this study is in accord with a recent study by Peltzer and Pengpid (2019).[19] They found out that 42.7% of Malaysian adolescents among their large sample study were sedentary. The slight differences between the studies is probably due to the age group of young adults that involves in the study. Besides Malaysia, the rate of sedentary behaviour in neighbouring countries such as Cambodia, Philippines, Indonesia, Myanmar and Thailand are also worrying ranging from 10.5% to more than 30% in some areas.[19] Studies from recent decades have pointed out that sedentary behaviour has been inflicting all age ranges from children up to the elderly, hence the unhealthy lifestyle indicates an alarming risk of global health burden.[3, 20-21]

Estimation of sedentary behaviour in this study was based on males' physical activity that was assessed via *SQuASH* questionnaire. The questionnaire was validated and previously utilised in multiple studies in Malaysia.[18] Uniquely, *SQuASH* was designed to suit repeated physical activity measurement for estimation of compliance to certain physical activity guidelines and the questionnaire was reported as reliable to be used for patients or healthy subjects.[22] Study has also proven that the *SQuASH* questionnaire is a valid self-reporting tool to measure physical activity energy expenditure in young adults.[23] Most physical activity questionnaires like the Baecke Habitual Physical Activity Questionnaire (BHPAQ) and the Vorrips questionnaire are not designed to estimate compliance of any guidelines.[24] The *SQuASH* questionnaire was designed to assess four categories of activities; commuting, recreational activity, nature of work and household activity. Categorisation of different domains allows for specific measurement of leisure time activities based on WHO characteristics.[25]

HRV analysis is widely used to characterise the functions of the autonomic nervous system (ANS) and the subclinical marker for heart problems. Generally, there are several factors that influence individual HRV such as hormonal and neural modulations, circadian changes, exercise, emotions, posture and preload.[26] This study focused on short-term HRV by stimulating the autonomic nervous system via VM and OTT. Short-term HRV is a convenient method to assess subjects in out-of-hospital settings. However, there are still limited studies available involving short-term HRV analysis that provides statistically relevant reference values for linear and nonlinear HRV indices from healthy subjects.[27] Therefore, this study is imperative to add reference values on the variation of short-term HRV with either sedentary or active lifestyle.

Recent studies have proven that short-term HRV analysis has been utilised in studies related to fall prediction, detection of mental stress and detection of training efficacy.[28-30] Based on this study, sedentary males showed significantly poor HRV as compared to subjects with active lifestyle. The findings prove that variation of HRV can be seen in early adulthood. In addition to the significant finding, the autonomic variations in SDNN among subjects with active lifestyle were also higher. Earlier studies revealed that the ratio of LF and HF spectral analysis was sensitive to the changes in ambient temperature. Therefore, the data collection was done under a controlled ambient temperature of 25^{o} – 27^{o}C to avoid any thermal bias between the two groups.[31] It was observed that within the controlled environment, a significantly higher LF/HF reading was recorded in the active group during VM. Hence, the result indicated that there was a higher sympathetic nerve stimulation found among them. Previous studies by Lizamore et al. have shown that 4 weeks of alteration in physical activity among adolescents significantly increased the HRV among their subjects and another intervention utilising adult population by Jones et al. have shown that 12 weeks of intervention has desirable intervention effects on HRV.[32,33]

The present study shows that there were significant differences in muscle strength between the sedentary and active groups. BMI is a part of the determinant for muscle strength, however, higher BMI in sedentary males for this study did not show any positive impact on muscle strength in the upper and lower body. High BMI that cause by high muscle mass would lead to better muscle strength. However, the higher BMI in sedentary subjects is contributed from the significantly higher body fat percentage. According to WHO, body fat of more than 24.9 is above normal value for adults.[34] Results from this study align with findings of previous studies

that pointed out the upper body muscle strength of more than 155.7 N is found in those who are active.[7,35] Preserving muscle integrity is important in preventing disability, physical frailty, fall and dependency in later life.[36] This situation warrants serious attention as a recent study in 2016 have revealed that 60% of Malaysian adults are classified as sedentary.[2]

The main limitation in this study involves the SQuASH questionnaire in which it is unable to specifically discriminate the specific duration of inactivity that significantly results in different HRV findings between the two groups. Another limitation that has been extensively debated in current research studies is the spectral analyses in pointing out the value that can be utilised as reference for either sympathetic or parasympathetic nerves stimulation. The gaps between studies may be due to the influence of artefacts between the studies. The conclusions of each work are still valid as the spectral analyses are interpreted based on the context of each study.[37]

CONCLUSION

This study indicates that the cardiovascular and musculoskeletal systems are highly impacted with sedentary behaviour at early age. Engagement in daily physical activities showed desirable balance in the function of autonomic nervous systems, hence reduces the risk towards cardiovascular diseases in later life. Furthermore, being active also preserves muscle strength that is important in maintaining quality aging. Future studies must emphasise on specific physical activities that are able to reverse autonomic imbalance and low muscle strengths due to sedentary lifestyle. Finally, parameters of HRV and muscle strength was found to be suitable markers to determine the changes brought by physical activities on physical health.

CONFLICT OF INTEREST

We declared no conflict of interest.

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