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Sedentary Lifestyle Implication on Cardio-Autonomic Function and Adaptation to Archery as a Reversible Intervention

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ABSTRACT

The study's objectives were to investigate the effects of a 12-week sedentary lifestyle on heart rate variability (HRV) and the effectiveness of archery as an intervention in a sedentary young population. 34 young people were divided into the sedentary group (SG) and the archery group at random (IG). While IG underwent a 12-week archery intervention with three sessions per week, SG was counselled to maintain their current way of life. At baseline, week eight, and week twelve of the intervention, two baroreflex tests—the Valsalva Manoeuvre Test (VMT) and the Orthostatic Tolerance Test—were used to assess HRV characteristics (OTT). The HRV parameters were determined using an Actiheart device. The SDNN and LF/HF ratio for Valsalva Manoeuvre Test (VMT) and Orthostatic Tolerance Test (OTT) showed gradual improvement from baseline, Week 8 and Week 12. SDNN parameters improve between +3% and +6.3% meanwhile SG showed a reduction at -0.5% and -3.5%. LF, HF, and LF/HF ratio readings also indicate improvement in IG participants. The blood pressure was calculated using PMBPI showed that IG constantly maintained the reading compared to SG which showed some fluctuation after 12 weeks. To conclude, the improvement of HRV parameter following 12 weeks of intervention suggest that archery training benefits in controlling autonomic nervous system changes due to prolong engagement in sedentary behaviors.

Keywords: archery, HRV, cardiac

INTRODUCTION

The commitment to a sedentary lifestyle causes limitations in physical activities. This situation changes the overall lifestyle, where people tend to spend more time on sedentary behaviours by increasing duration on the screen and prolonging sit or sleep. Furthermore, it also causes an increased amount of intake which leads to an imbalance in energy consumption (Fletcher et al., 2018). As a consequence, the fat mass and percentage are about to increase. The adaptation of more to sedentary behaviours and imbalance energy consumption caused the modification of the physiological interaction of vital organs especially the cardiovascular system (Young et al., 2016).

Various studies have found that increased sedentary behaviour leads to a decline in cardiovascular indices (Fenton et al., 2017; Young et al., 2016). As a result, prolonged low-quality daily physical activity reduces cardiovascular fitness, which may eventually impair the ability to complete certain tasks. In order to reverse the undesirable impact, changes in lifestyle and minimizing the duration of sedentary behaviours should be implemented soon (Bangsbo et al., 2015; Halloway et al., 2015). Football and hockey are among the sports activities that have good impacts on cardiac fitness (Bricout et al., 2010; Cipryan et al., 2007). Unfortunately, those activities require direct physical contact with other players, which is prohibited by the quarantine instructions. During this time, the activity should be able to be performed on its own while still improving overall cardiac function.

Archery is one of the good activities that should be considered to enhance physical activity. Even though actual activity requires special ranges, some modifications could be made. The shooting range can be shorter and narrower, suitable for indoor or outdoor activities. Furthermore, traditional archery is a simple yet effective alternative to modern archery. Traditional archery has a basic requirement to play, which is the bow and arrow. Compared to modern archery, the traditional bow has not been equipped with any assistive devices such as a stabilizer, clicker, and so on. However, there is no significant difference in the shooting technique.

Archery requires sustainable muscle strength, good body posture, focus, and breathing control because there are no assistive devices to help archers (Grayson et al., 2007; Johnson, 2015). Throughout the whole process, the archer needs to maintain isometric contraction and slow breathing control during archery. Low-intensity isometric activity performed over time has a similar effect on the heart rate response as high-intensity isometric activity (Leite et al., 2010). Similarly, in archery, the aiming phase requires archers to maintain the string withdrawal for a few seconds with a low string weight. Related to archery, prolonged involvement contributes to greater parasympathetic activity and a lower LF/HF ratio (Carrillo et al., 2011; C-T Lo et al., 2008).

Archery, like other sports, has been shown to improve cardiovascular function, particularly in the active population (Lee & Mendoza, 2012; Schmidt et al., 2014). Most of the studies were conducted on athletes rather than inactive subjects to evaluate the effect of archery. Furthermore, the majority of them focused on modern archery, with little attention paid to traditional archery. In the current study, young people who led sedentary lifestyles had their cardiovascular fitness assessed after archery training.

PARTICIPANTS AND METHODS

Written informed consent was signed by all volunteers after a briefing session with the researcher. The aims, risks, and benefits were included in the briefing point. The study was conducted according to the Declaration of Helsinki and approved by the Universiti Sains Islam Malaysia Ethic Committee (USIM/REC/0416-3). In addition, informed consent was also obtained from each of the participants prior to initiating data collection.

Thirty-four sedentary youth were randomly allocated into a sedentary group (SG) (n = 17; height = 167.2 5.8 cm, weight = 86.3 22.0 kg, BMI = 30.8 6.8 kg/m2) and an intervention group (IG) (n = 17; height = 165.7 5.2 cm, weight = 81.1 16.3 kg, BMI = 29.5 5.4 kg/m2). Those who had a history of cardiovascular and respiratory problems, neurological deficiency, or recent physical injury, especially to the upper and lower body, were excluded. Throughout the intervention period, no participants withdrew or were excluded.

There were two tests to carry out for all who participated in the study: the Valsalva Manoeuvre (VMT) and the Orthostatic Tolerance Test (OTT). Participants first did VMT before OTT and then rested for 10 to 15 minutes.

The Actiheart device (CamNTech Inc., England) was initially equipped with participants' particulars (name, age, date of birth, and resting heart rate). The electrocardiogram (ECG) electrodes were adhered at V4 and V5, or along the 5th intercostal space. The Actiheart device is fixed to the ECG electrodes. The researcher reminded the participant to report any unpleasant signs and symptoms, such as dizziness and headaches, during or after the procedure.

Before conducting VMT, participants were instructed to rest for at least 2 minutes for heart rate recovery (Ghaffari et al., 2011). The participant sat on a back-resting chair with both hands relaxed on a table. Meanwhile, the researcher prepared the blowing circuit by attaching a mouthpiece to a manual sphygmomanometer tube. After the resting period ended, participants were instructed to perform force expiration via a mouthpiece and maintain the pressure at 40 mmHg for 15 seconds (O'Brien et al., 1986). The tests were repeated twice with a two-minute interval between each test.

For OTT, readings of blood pressure (BP) were taken simultaneously during the test. Upon starting the test, the subject was in a lying position for 5 minutes, and BP and HR readings were recorded. Later, the subject was instructed to abruptly stand upright and maintain the position for one minute. BP and HR readings were recorded immediately. The same procedure was performed twice. The BP reading was measured using an OMRON automatic blood pressure monitor (series: HEM-7120) (www.omronhealthcare.com). The left arm was supported on the table so the cuff could be at the same level as the heart. The cuff was placed about 1–2 cm above the cubital fossa and was firmly fastened around the arm.

No changes were intended to daily living activities for participants under SG. In fact, they were required to maintain their current lifestyle. They also advised against participating in strenuous activities or structured strength training. Meanwhile, a minor change to the IG participants' lifestyle was proposed, which included the addition of three days of archery activity per week. They were required to shoot 7 arrows per session (for 6 sessions per day) in a 10-meter shooting range using a naked recurve bow (35 lbs of string weight). A total of 12 weeks of intervention was set for both SG and IG. There were three phases of data collection; Figure 1 represents a schematic illustration of the study design.

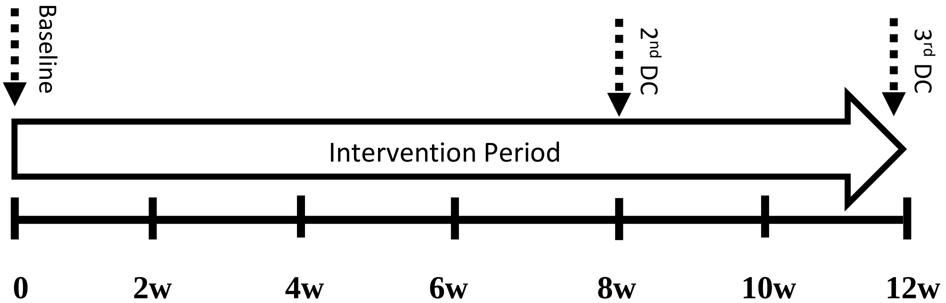

Fig. 1. Schematic illustration of the intervention protocol. The intervention period was 12. For the intervention period; 3 times of data were taken within 12 weeks interval. HRV for the Valsalva maneuver and orthostatic tolerance test were measured by the Actiheart device.

RESULTS

Three series of data were collected within 12 weeks of investigation for both groups. ANOVA was used for the first analysis. Repeated measures are needed to evaluate the time effect, group effect, and intervention effect. Then, pair-wise analysis was used to evaluate significant differences based on each individual group.

SG expected no significant changes in all effects (time, group, and intervention) after a sustained commitment to sedentary behaviors. For VMT, some parameters showed negative development on SDNN and HF values (Table 1). The SDNN value was 1%, while the HF value was even lower at -61%. The LF/HF ratio showed quite similar readings to the baseline, with 10% changes. Meanwhile, for OTT, similar trends were recorded in all tested parameters (Table 2). In addition, the SDNN value fell by about -3.5% compared to the baseline. The HF value was also reduced by 1%. The reduction of the HF value in OTT influenced the elevation of blood pressure, which increased by 12% compared to the baseline reading.

With the addition of archery activity, IG generally showed on the majority of tested parameters. In the case of VM, the LF/HF ratio improved significantly ($p< 0.05$) at Week 12 compared to the baseline, and it improved nearly ninefold (+90%). The SDNN value had an improvement of about 6.3%. Despite no changes to the LF, it improved by 78%. Meanwhile, for OTT, the LF/HF ratio also changed significantly ($p<0.05$) between Week 12 and baseline, which improved about threefold (+75%)

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compared to CG. The SDNN value increased by 3.4%, the LF value increased by 36%, and the HF value increased by 9%. The stability of HRV in OTT prevented BP readings from fluctuating further during rapid body positioning changes.

DISCUSSION

The present study aimed to evaluate the effects of a sedentary lifestyle on cardio-autonomic function and further examine the effect of archery activity among youth. According to the World Health Organization (WHO), a sedentary lifestyle refers to those who perform less than 150 minutes of moderate-to-vigorous physical activity (MVPA) a week. Sedentary behaviours in current lifestyles are typical due to certain activities, mainly in the working environment (Hopkin & Sarkar, 2016), educational system (Wang et al., 2013), and weekend pattern (Martnez-López et al., 2015). Increased sedentary behaviour on a daily basis may alter the efficiency of the autonomic nervous system, affecting body systems, particularly the cardiovascular system.

The present study found that important parameters of heart rate variability (HRV) obtained in sedentary subjects showed some reduction. Despite the small changes, over time, they could lead to greater declination, which would affect cardiac function.The SDNN value is an important indicator for predicting cardiac morbidity and mortality (Shaffer et al., 2017).Traditional studies suggested that a low SDNN value represents an unhealthy population when the reading is less than 50 ms (Kleiger et al., 1994; Stein et al., 1994). The good health norm reading is set higher than 100 ms (Shaffer et al., 2017). Both IG and CG were classified as having compromised health in the current study because their SDNN readings were between 80 and 90.These moderate readings were obtained exclusively from the participants, who had very low participation in leisure-time activities at baseline. From the obtained data, SDNN showed a small decline after 12 weeks in SG, while IG obtained positive improvement in VMT and OTT. Although the percentage of deterioration was low, it still indicated a negative sign.Moreover, with an increase in BMI and prolonged sitting, the SDNN values will continuously decrease (Adam et al., 2017; Hallman et al., 2015; Karason et al., 1999) and eventually increase the risk of cardiovascular disease (Stein et al., 1994). Therefore, even the reduction in SDNN value is considered small, but the combination of the impact of sedentary behaviour, improper eating behaviour, imbalanced caloric intake and expanses, and an increased BMI might accelerate the incidence of cardiovascular disease. On the other hand, archery intervention improved SDNN values in IG, which highlights the benefits of exercise. A meta-analysis (Hillebrand et al., 2013) concluded that every increase of 1% in the SDNN value reduces about 1% of cardiovascular incidence. As a result of the current study, archery activity reduced the risk of cardiac events by at least 6%.

The low frequency (LF) and high frequency (HF) furthermore indicate the SNS and PSNS values. The interaction between SNS and PSNS is obtained from the reading of the LF/HF ratio. Following 12 weeks of sustained sedentary activity, SG showed uncertain pattern readings of SNS and PSNS. Meanwhile, archery intervention observed an improvement in SNS and sustained PSNS readings in IG after 12 weeks.This change demonstrates the interaction of the autonomic nervous system (ANS), particularly the heart's coping strategy, with certain physical events.From a meta-analysis review, the normal mean of the LF/HF ratio is set at 2.8 (Shaffer et al., 2017). The present study reported that both groups were above the normal value for the LF/HF ratio. The reduction in lower PSNS is responsible for the impact. Consistent studies have mentioned the importance of exercise in reversing the low HRV and improving PSNS and SNS interaction (Melanson & Freedson, 2001; Nummela et al., 2016; Oliveira et al., 2013). The moderate to vigorous intensity (MVI) was reported to enhance the capability of the heart to cope with prescribed activities (Oliveira et al., 2013). Archery, despite being outside of the MVI range, has been shown to improve the PSNS and provide a better balance of interaction between the PSNS and the SNS (C.-T. Lo et al., 2008).A good balance of PSNS and SNS is important in maintaining the reading of HRV even with very rapid postural changes (Martinelli et al., 2005). This is critical because low HRV readings are associated with a 32-45% increased risk of a first cardiovascular event in people who do not have a history of cardiovascular disease (Hillebrand et al., 2013).

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Table 1. Valsalva maneuver characteristics before and after intervention

Parameters	Baseline	Week 8	Week 12	*p* (partial ETA square)		
				Time Effect	**Group Effect**	**Intervention Effect**
Valsalva Manoeuvre						
Average Max						
Control	869.1±152.8	841.6±157.0	886.8±120.5	0.37 (0.03)	0.25 (0.04)	0.94 (0.01)
Intervention	921.1±154.6	897.3±150.3	925.6±163.0			
Average Min						
Control	646.8±73.3	631.8±59.1	653.4±62.6	0.92 (0.01)	0.08 (0.09)	0.45 (0.03)
Intervention	667.8±82.3	686.6±85.5	673.9±73.8			
Average Max/Min						
Control	1.3 ± 0.2	1.3 ± 0.2	1.4 ± 0.2	0.44 (0.03)	0.80 (0.01)	0.78 (0.01)
Intervention	1.4 ± 0.2	1.3 ± 0.2	1.4 ± 0.2			
Average SDNN (ms)						
Control	81.8 ± 34.5	79.5 ± 42.9	81.4 ± 36.1	0.88 (0.01)	0.86 (0.01)	0.91 (0.01)
Intervention	80.9 ± 35.7	81.7 ± 34.0	86.0 ± 44.5			
Average Low Frequency						
Control	2586.9±1811.6	2664.4±3211.7	2612.9±2187.6	0.29 (0.04)	0.64 (0.01)	0.33 (0.03)
Intervention	2025.8±1835.1	3240.8±3037.7	3610.5±3866.7			
Average High Frequency						
Control	2045.9±2935.3	1115.6±1751.2	792.5±560.2	0.08 (0.08)	0.62 (0.01)	0.13 (0.06)
Intervention	1133.1±1646.5	913.2±1248.7	1131.4±1923.3			
LF/HF Ratio						
Control	3.1 ± 2.5	3.5± 2.4	3.4 ± 1.9	0.01 (0.15)*	0.11 (0.08)	0.12 (0.07)
Intervention	3.0 ± 2.1	6.7 ± 7.1	5.6 ± 3.1[b]			

* $p < .05$ – significant difference using repeated measures ANOVA
[a] $p < .05$ – significant difference using pairwise analysis between baseline and Week 8 based on individual group
[b] $p < .05$ – significant difference using pairwise analysis between baseline and Week 12 based on individual group

Table 2. Orthostatic tolerance characteristics before and after intervention

Parameters	Baseline	Week 8	Week 12	*p* (partial ETA square)		
				Time Effect	Group Effect	Intervention Effect
Orthostatic Tolerance						
Average Max						
Control	1068.5±226.5	1021.6±212.2	1037.9±207.6	0.17 (0.05)	0.86 (0.02)	0.89 (0.01)
Intervention	1061.4±171.9	995.6±140.8	1040.0±211.4			
Average Min						
Control	523.6±78.0	538.5±83.5	540.1±57.0	0.81 (0.01)	0.43 (0.02)	0.69 (0.01)
Intervention	549.3±49.2	547.1±61.4	546.9±51.6			
Average Max/Min						
Control	2.1 ± 0.4	1.9 ± 0.4	1.9 ± 0.2	0.29(0.08)	0.53 (0.01)	0.70 (0.01)
Intervention	1.9 ± 0.3	1.8 ± 0.4	1.9 ± 0.5			
Average SDNN						
Control	97.8 ± 37.8	100.7± 44.5	94.4 ± 34.6	0.98 (0.01)	0.56 (0.01)	0.50 (0.02)
Intervention	91.4 ± 30.1	87.0 ± 35.7	94.5 ± 41.3			
Average Low Frequency						
Control	1361.1±1024.6	1440.1±1011.1	1767.4±1624.2	0.24 (0.04)	0.68 (0.01)	0.99 (0.01)
Intervention	1216.2±1345.5	1253.9±857.7	1657.8±1939.5			
Average High Frequency						
Control	701.3±602.3	645.6±660.3	699.4±731.6	0.59 (0.01)	0.92 (0.01)	0.78 (0.01)
Intervention	744.8±759.2	560.2±632.3	811.7±1574.1			
LF/HF Ratio						
Control	2.8 ± 2.1	3.5 ± 2.1	3.4 ± 2.0	0.01 (0.30)*	0.64 (0.01)	0.12 (0.07)
Intervention	2.0 ± 1.0	3.4 ± 1.7[a]	3.5 ± 1.6[b]			
Blood Pressure						
PMBPI						
Control	9.3 ± 4.3	10.6 ± 6.0	10.5 ± 6.3	0.81 (0.01)	0.29 (0.04)	0.95 (0.01)
Intervention	8.0 ± 14.5	8.9 ± 4.5	8.1 ± 5.2			

* p< .05 – significant difference using repeated measures ANOVA
[a] p< .05 – significant difference using pairwise analysis between baseline and Week 8 based on individual group
[b] p< .05 – significant difference using pairwise analysis between baseline and Week 12 based on individual group

Due to the uncertainty of the HF, LF, and HF/LF ratio values, the blood pressure readings also get affected. The blood pressure showed some elevation following the lack of physical activity. It increases the fat deposition elements, which are responsible for contributing to a higher blood pressure reading. Meanwhile, the subject in IG was reported to have good blood pressure maintenance following 12 weeks of intervention. The interesting results were obtained from the method that was embedded in the archery game itself. The isometric hand grip is actually implemented during archery training, especially while gripping the bow and withdrawing the string. The holding duration of 5 to 10 seconds that was performed during the training could help in improving baroreflex sensitivity and controlling systolic blood pressure. Millar et al. (2013) discovered that isometric hand grip strength reduced systolic blood pressure readings while increasing heart rate complexity. Similarly, Baross et al. (Baross et al., 2017) and Somani et al. (Somani et al., 2018) found that isometric handgrip exercises had positive effects on systolic blood pressure at rest. Besides, the controlled breathing technique at 12 breaths per minute helps in reducing SNS effects and allowing no changes in BP (McClain et al., 2017). This is a fascinating fact since archers frequently employ proper body posture and breathing control during the shooting process. Moreover, slow and deep breathing is also responsible for improving HRV readings (Mlynczak et al., 2016; Steffen et al., 2017). In addition, good posture also enhances the movement of the diaphragm (Mohd Azrul Anuar et al., 2013), which allows for slow, deep, and controlled breathing.

Sedentary lifestyles are associated with an imbalance in cardio-autonomic function and may reduce the heart's ability to cope with stressful activities. The findings suggest that a sedentary lifestyle will increase the mortality of cardiac events in the future. On the other hand, with the great improvement offered by archery intervention, this activity is very crucial to being expanded as one of the health sports. Every movement in archery improves autonomic nervous system interaction and leads to good cardiac function. Furthermore, this study introduced traditional archery that merely served as an intervention rather than the modern type. The traditional form of archery uses a naked recurve bow with no assistive devices attached to the bow. As a result, the effort required to withdraw and sustain the string while shooting is entirely the archer's responsibility. To correlate with the present study, these positive results were developed from the participants' definite strengths and capabilities.

CONCLUSION

Finally, controlling and reducing sedentary behaviour improves heart physiological activity. Changing one's lifestyle to be more active will improve one's quality of life in the future. The archery intervention has reversible benefits for sedentary behaviour effects, particularly the interaction of PSNS and SNS. With improvements to these interactions, the cardiovascular system could be improved, especially in terms of function and coping capability. The positive results were obtained only from the archery intervention. Therefore, additional interventions in nutrition and motivation could be suggested for future studies.

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