ORIGINAL ARTICLE

Effects of Isometric and Isotonic Lower Limb Circuit Exercises on Cardiovascular Responses in Young Adults.

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Abstract

Introduction: The study aims to investigate the immediate effects of isometric and isotonic lower limb circuit exercises on young adults.
Materials and Methods: 100 subjects were recruited within the inclusion and exclusion criteria. All subjects underwent both lower limb isotonic and isometric circuit exercises which consist of squats, front lunge, standing leg raise and lateral lunge. A baseline heart rate, blood pressure and ECG were measured. After the completion of each circuit exercises, the cardiovascular parameters were measured again.
Results: A significant increase of systolic blood pressure (SBP) was observed after isotonic circuit exercises ($p<0.05$). Significant decrease of diastolic blood pressure (DBP) was observed after isometric lower limb circuit exercise ($p<0.05$). Heart rate (HR) was seen to increase significantly after both isometric and isotonic lower limb circuit exercise. Significant QT shortening was also observed after isometric and isotonic lower limb circuit exercise ($p<0.05$).
Conclusion: In conclusion, the findings showed that the blood pressure and heart rate did not increased excessively after both isometric and isotonic lower limb circuit exercises. The reduction of DBP recorded after both isometric and isotonic circuit exercises is a positive finding and this signifies that there is a decrease of peripheral resistance post exercise.

Keywords
Blood pressure, cardiovascular responses, isometric, isotonic, circuit exercises, heart rate.

Introduction

Regular physical exercise has been proven to offer multiple beneficial effects on our overall health. Benefits of regular exercising include improves cardiovascular health, increase muscles and bone strength, and to prevent diseases such as type 2 diabetes, and obesity.[1] There are several factors that leads to the development of cardiovascular disease and the most well-known factor is sedentary lifestyle.[2] [3] Exercises such as jogging, playing football and badminton are the most common exercises among Malaysians while tai chi, swimming and working out in the gymnasium are the least popular due to time consumption, high cost of entrance fees and lack of commitment.[4] Hence, circuit exercise or interval training at home with no equipment will be beneficial for Malaysians as these exercises are low cost and less time consuming.[5] Studies showed that circuit exercises met the qualifications for an effective cardiovascular and muscular workout, thus, circuit exercise is the most effective method for increasing muscular strength.[6][7][8]

Circuit exercise which consists of exercises in series with 15 to 30 seconds rest in between exercises, was originally developed by Morgan and Anderson in 1953 at the University of Leeds, England.[9] The series of exercises consist of isotonic and isometric exercises. During isometric exercises, a constant intramuscular pressure was generated on the blood vessels, and limits the blood flow, oxygen delivery and increases the peripheral vascular resistance, thus leading to a rise in blood pressure. In contrast, isotonic exercises consist of two phases; contraction and relaxation phase. The blood flow is only restricted during the contraction phase of isotonic exercise.[10][11] The different mechanical properties of these two muscular contractions may have an effect on the blood pressure and other cardiovascular responses such as heart rate and electrical activity of the heart. It is reported that isometric exercises can result in elevated diastolic blood pressure and cardiac patients were cautioned about isometric exercises requiring static muscle contractions, because these exercises are associated with increased cardiovascular stress.[10][12][13] Thus, understanding of the cardiovascular responses to circuit exercises will be useful for clinicians and physiotherapists.

Several researchers have investigated the effects of circuit exercises on cardiovascular responses. Circuit exercises has been shown to be a safe intervention in cardiac rehabilitation programme but did not further investigate on the isotonic and isometric contractions of the circuit exercises on cardiovascular responses.[14][15] Significant reduction in arterial blood pressure and heart rate were observed after 6[16][17] and 12 weeks[18] of circuit exercise training. It is important to assess the cardiovascular response such as QT interval after exercise recovery to prevent unfavourable cardiac events. To our knowledge, there are no studies which investigated the effects of isometric circuit and isotonic circuit exercise on blood pressure, heart rate and QT interval. The aim of this study, therefore was to examine the immediate effects on blood pressure, heart rate and QT interval.

Methods

Participants

The study was conducted on 100 young adults of University Kuala Lumpur, Malaysia in the age group of 18 to 24 years old. A questionnaire was done and subjects within the age group were selected. Subjects with history of recent injuries of lower limbs, cardiovascular or respiratory pathologies were excluded from the study. The study chose to eliminate subjects with these pathologies in order to establish the cardiovascular effects of lower limb isometric and isotonic circuit exercises without any pathology. All subjects acknowledged their

understanding of the study, risks, termination of participation and written consent was obtained. Ethical approval from the UniKL Research Ethics committee was obtained before performing the study.

Measurement

The height and weight were recorded in centimeters and kilogram respectively and body mass index (BMI) was calculated using the formula weight in kg/ (height in meter)^2. Littman stethoscope was used with sphygmomanometer to measure the blood pressure while heart rate was recorded using a 12 lead Electrocardiogram (ECG). A baseline assessment of heart rate (HR), systolic (SBP), diastolic blood pressure (DBP) and ECG was measured. Prior to the measurements, subjects were asked to sit in the research lab with a quiet environment for 5 minutes. For male subjects, they were asked to remove their upper clothing while the female participants were asked to remove underwired bra which can interfere with the ECG readings. The ECG electrodes were then attached to the participants' clean skin without hair or any substance. During the entire measurement, the participants were in a relaxed half lying position and they were asked not to speak, and avoid any movements. The subjects then performed the assigned exercise and returned to the initial resting position after completion of the circuit exercises. Blood pressure and heart rate were measured again, within 2 minutes to determine the immediate effects of the isotonic and isometric lower limb circuit exercises. The same measurement protocol was repeated when the subjects returned for the next assigned exercise.

Exercise Protocol

The lower limb circuit exercises consist of squats, front lunges, standing leg raises and lateral lunges. Each of the sub-exercise in the lower limb circuit can be done in an isotonic and isometric way. All subjects underwent both lower limb isometric and isotonic exercises. For isometric lower limb circuit, subjects were required to hold in a sub-exercise position for one minute followed by 30 seconds rest before performing another sub-exercise position. For isotonic lower limb circuit, subjects completed as many repetitions as possible in a controlled manner for each sub-exercise position within one minute. They were given 30 seconds rest between each sub-exercise. All subjects completed two rounds of isotonic and isometric circuit exercises. Prior to the testing, subjects were familiarized with the lower limb circuit exercises by proper instructions and practice. Demonstrations were given by a physiotherapist. All subjects were also given 5 days gap of rest to allow for recovery of muscle soreness.

Statistical Analysis

Descriptive data was summarized as mean ± SE. For evaluation of statistical data, Statistical Package for Social Sciences (SPSS) (SPSS ver. 21.0, Armonk, NY, IBM Corp) was used. Paired t-test was used to compare intra group pre and post exercise cardiovascular parameters. Level of significance was set at $p<0.05$.

Results

A total of 100 healthy normotensive participants completed the study. The age group was between 19 to 23 years with average weight of 59.05kgs, height of 160.21cms and BMI of 21.45kg/m^2 (Table 1). An increase of mean SBP was observed after both isometric and isotonic lower limb circuit exercises. However, the increased of mean SBP is significant after isotonic lower limb circuit exercise ($p<0.05$). In this study, the mean DBP decreased significantly after isometric lower limb circuit exercise ($p<0.05$). Mean heart rate increased significantly after both isometric and isotonic lower limb circuit exercise ($p<0.05$) while mean duration of QT interval shortens significantly ($p<0.05$). (Results are shown in Table 2 and 3).

Discussion

Effects of isometric and isotonic circuit exercise on blood pressure

The study observed a rise of mean SBP after both isometric and isotonic lower limb circuit exercises but more significant after isotonic lower limb circuit exercises ($p<0.05$). The increased of SBP indicates that there is an increased of cardiac output after exercises, thus leading to increase of blood flow to skeletal muscles. In isotonic exercises, the muscles contract and relax rhythmically which allows adequate blood flow to the muscle leading to the rise of SBP. Meanwhile in isometric exercises, the muscles remain in contracted state resulted in static compression of blood vessels which impedes blood flow to muscles.[19] [20] Due to the limitation of oxygen delivery during isometric exercises, the exercise pressor reflex response is activated which then leads to the increased of blood pressure and cardiac output.[21] The results of this study are consistent with several studies have also shown significant elevations of systolic blood pressure in response to isometric and isotonic knee extension exercises.[23][24][25][26][27]

However, this study found that mean DBP decreases significantly after the lower limb isometric circuit exercises ($p = 0.04$) when compared to isotonic circuit exercises ($p = 0.09$). The significant decrease of diastolic blood pressure after isometric circuit exercises can signify a decrease in peripheral resistance after the exercise ceases and during the recovery period. In other studies, isometric exercises are found to increase blood pressure and heart rate because of the obstruction of blood vessels in the muscles, raising the total peripheral resistance which then later increases the afterload of the heart.[25][27][28] However, the exact mechanism of the cardiovascular responses to isometric and isotonic exercises is still not well understood.

Effects of isometric and isotonic circuit exercise on heart rate

The heart rate readings were obtained using the R-R interval recordings of the ECG. Similar to the results of other studies, the mean heart rate rises significantly after both isometric and isotonic circuit exercises. Heart rate was expected to rise exceeding the safe limits but it did not increase as much because blood vessels of young adults are often easily adjusted. This may be due to the Windkessel effect on young adult's vessels which are still elastic to prevent excessive rise so that blood pressure can remain as normal as possible.[29]

Effects of isometric and isotonic circuit exercise on QT interval

QT interval represents the electrical activity of the heart's ventricle which includes the depolarization and repolarization of the heart. There were some studies reported on prolongation of QT interval after isometric exercises, and there is no study that has been done to investigate the effects of isometric and isotonic circuit exercises.[30], [31] A prolongation of QT interval may lead to fatal arrhythmias. In our study, the QT interval was found to decrease significantly after both isometric and isotonic lower limb circuit exercises ($p<0.05$). The shortening of QT interval after exercises were consistent with other studies which also investigated on the effects of exercises on QT interval.[32][33][34] The study demonstrated that as the heart rate increases, the shorter the QT interval. Our study did not show any prolongation of QT interval after isometric and isotonic circuit exercise. However, our study had used a different exercise protocol and the changes of QT interval may be due to different intensities of exercises which is still difficult to explain. Further studies need to be done to evaluate the QT-RR relationship so to provide important information on the effects of circuit exercises.

Limitations

This study attempted to investigate the immediate effects of isometric and isotonic lower limb circuit exercises in normotensive individuals in a university. The results of this study cannot be generalized. Further research need to be explored on hypertensive population to determine the immediate effects of isometric and isotonic circuit exercises on cardiovascular responses. It will also be beneficial to investigate the immediate effects of circuit exercises on upper limb as different muscle mass may have an influence on the cardiovascular responses.

Table 1. Demographic characteristics.

Characteristics	**Summary**
Gender (Male/female)	49/51
Age (yrs)	20.09 ± 1.05 years
Weight (kg)	59.05 ± 2.89
Height (cm)	160.21 ± 1.68
BMI (kg/m^2)	21.45 ± 1.83

Table 2. Pre and post isometric lower limb circuit exercise's blood pressure and heart rate. (Mean±SE, n=100)

Cardiovascular parameters	**Pre exercise**	**Post isometric lower limb circuit exercise**	**P value**
SBP (mmHg)	112.63 ± 0.77	114.33 ± 1.09	0.130
DBP (mmHg)	75.63 ± 0.77	73.61 ± 0.83	0.037
HR (beats/min)	75.67 ± 1.12	85.97 ± 1.03	0.000
QT interval (s)	0.33 ± 0.003	0.31 ± 0.002	0.000

Table 3. Pre and post isotonic lower limb circuit exercise's blood pressure and heart rate. (Mean±SE, n=100)

Cardiovascular parameters	**Pre exercise**	**Post isotonic lower limb circuit exercise**	**P value**
SBP (mmHg)	112.63 ± 0.77	115.10 ± 1.17	0.049
DBP (mmHg)	75.63 ± 0.77	73.85 ± 0.94	0.085
HR (beats/min)	75.67 ± 1.12	94.69 ± 1.28	0.000
QT interval (s)	0.33 ± 0.003	0.29 ± 0.003	0.000

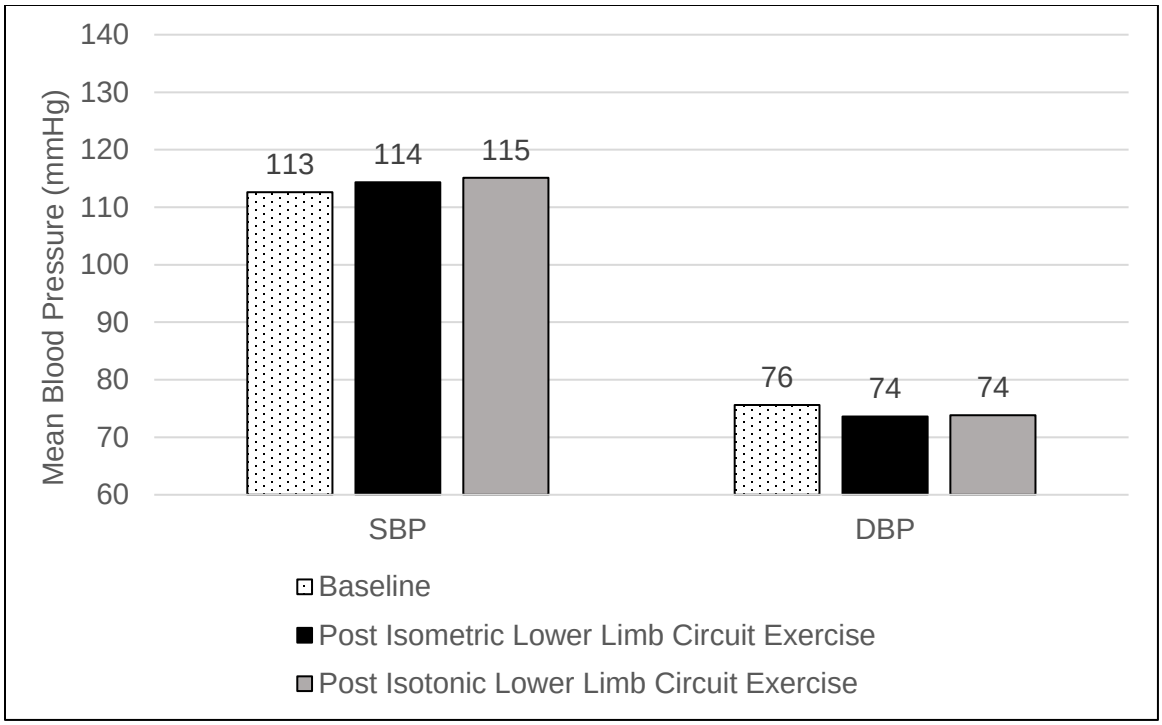

Figure 1. The effects of isometric and isotonic lower limb circuit exercise on blood pressure.

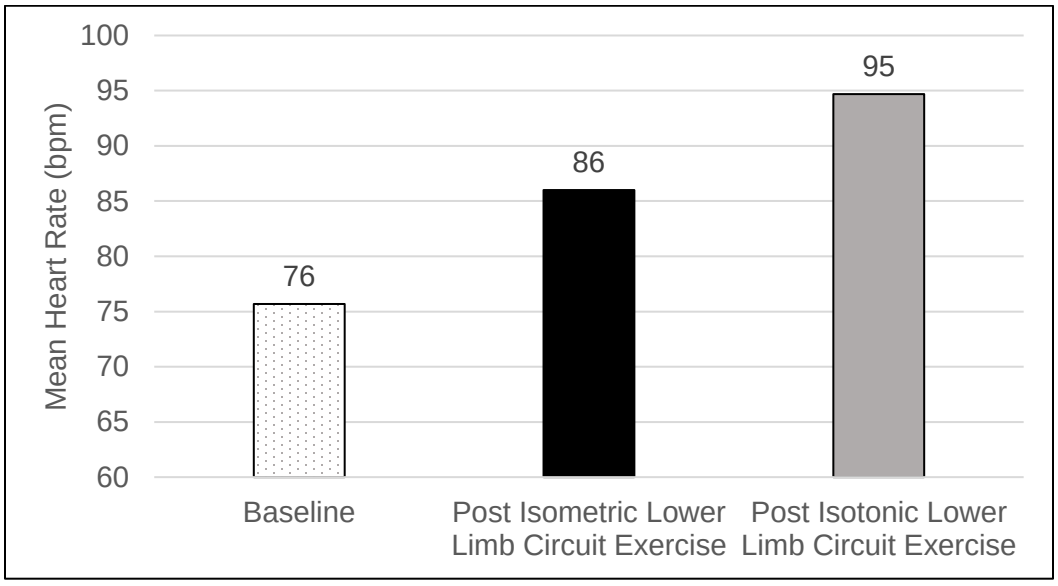

Figure 2. The effects of isometric and isotonic lower limb circuit exercise on heart rate.

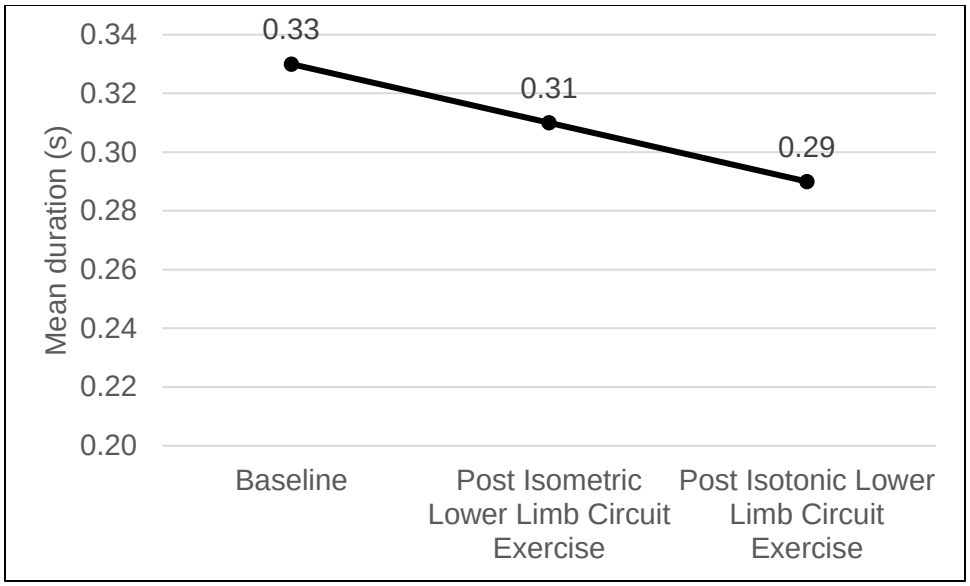

Figure 3. The effects of isometric and isotonic lower limb circuit exercise on QT interval.

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