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# TO QUANTIFY EFFECT OF EXERCISE ON BRACHIAL ARTERY BY DOPPLER STUDY

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**Abstract**
**Background: Aim and Objective:** The aim of the study was to quantify the effect of exercise on brachial artery in healthy individuals using vessel diameter and pulsatility index on doppler study. **Materials and Method:** Twenty healthy adults were included in the study, all under twenty five years of age. They were made to answer a questionnaire which comprised of any symptoms related heart disease and peripheral vascular disease. Written consent was obtained. Harvard step test was conducted on all individuals. Doppler study was conducted on all the individuals before and after the step test. Results: It was noted that there is dilatation of the brachial artery and reduction of the pulsatility index after the exercise. It was observed that the diameter of the vessel increased by 7-15 percent while pulsatility index reduced by 40 to 65 percent. **Conclusion:** The findings concluded that doppler indices of vessels like brachial artery which can be easily imaged can help to predict vascular diseases like cardiovascular abnormality or peripheral vascular disease.
**Key words:** Vessel diameter, Pulsatility index, Harvard step test.

## Introduction

Cardiovascular diseases (CVD), including coronary heart disease, cerebrovascular disease and peripheral vascular disease are responsible for more than half of all total deaths. Despite significant declines in CVD mortality, recent data shows that CVD still remains the leading cause of mortality worldwide, and is responsible For one third (17.8 million) of all deaths (WHO, 2011). This figure is predicted to rise to 30 million by 2030 due to the increasing incidence of CVD in low and middle income In addition to these, CVD also causes extensive disability

Doppler ultrasound scan technology is widely used as a cheap, readily accessible, noninvasive bedside imaging modality which provides high quality anatomical images of the blood vessels. The most important advantage of Doppler ultrasound over other imaging

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methods is that it provides a real-time assessment of blood flow and it is free of ionising radiation.

For the assessment of hemodynamic changes, it is necessary to determine some parameters of the blood flow. These include the maximum systolic velocity (S), the minimum diastolic velocity (D), the S / D ratio (systolic/diastolic ratio), the acceleration index (AI) , the acceleration time (AT), the pulsatility index (PI) and the resistivity index(RI). In this study we have used pulsatility index as the only index coupled with vessel diameter. PI is the difference between the peak systolic and minimum diastolic velocities divided by the mean velocity.

Exercise training contributes to a significant increase in brachial artery flow-mediated dilation (BAFMD). Exercise training interventions, of greater intensity and duration, may optimize the increase in BAFMD. Previous studies have demonstrated conflicting results on the effects of acute exercise on FMD. At rest, changes in the PI may not always be a precise indicator of vessel stenosis. However, a few studies have used the PI following exercise, which may provide additional information on hemodynamics like to examine the exercise-related time course of the PI in the brachial artery after ischemic or non-ischemic isometric handgrip exercise (IHE) using Doppler ultrasound, and to determine the potential use of this parameter as an indicator of vascular disease.10

Doppler ultrasonography proved a practical tool in the studies of the dynamic responses of blood flow and vascular resistance during rest and exercises. Doppler ultrasound measures during both rest and exercise is reproducible across different test days and can be used as a reliable, noninvasive means of testing hypotheses related to blood flow control.

**Materials And Methods**

Twenty healthy adults were taken as members for the study. All of subjects were males.

**Exclusion criteria:**

Subjects below twenty years of age and above 25 years of age were excluded.

Subject at risk for cardiovascular disease such as hypertension, hyperlipidemia, diabetes.

Consent was obtained from all. Harvard Step Test was conducted on all. Doppler findings {Pulsatility index in brachial artery} and artery diameter was recorded before and after the test.

To ascertain the validity and reliability of ultrasound, to quantify muscle blood flow during dynamic exercise, participants will perform The Harvard Step Test.

The Harvard Step Test is used to measure aerobic fitness, being a predictive test of their VO2max. It tests the cardiovascular system and reflects the general capacity of body to cope with increased physical work load and ability to recover from it. This test is simple to conduct and requires minimal equipment. Participants step at a rate of 30 steps per minute for 5 minutes.

**Pulsatility index**

The pulsatility index (PI) quantifies the shape of the blood velocity waveform and was defined as the peak-to-peak amplitude of a wave- form, divided by the mean amplitude over the cardiac cycle, as previously described by Gosling and King (1974). Previous studies have reported the physiological significance of PI, which reflects downstream resistance to flow and the correlation between vessel resistance and PI has been closely demonstrated (Gosling

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and King 1974; Evans et al. 1980; Skidmore et al. 1980; Legarth and Nolsoe 1990). Thus, PI may be used as an effective indicator of changes in peripheral vascular resistance following exercise. Measuring the PI of the blood velocity waveform in the conduit artery supplying the muscle can easily assess vascular impedance after exercise. The index of vessel resistance obtained by using the PI was automatically calculated according to the following formula:
PI= (Vmax – Vmin) / Vmean,

**Results**

All twenty individuals brachial artery diameter and pulsatility index was recorded before and after the Harvard Step Test. It was found that the diameter of the brachial artery increases and pulsatility index reduces. The change varied in every individual. The range of arterial dilatation was 7 to 15 percent {after the step test}. The pulsatility index reduced by 40-65 percent {after the step test}.

**Table 1**

| | | | **SONOGRAPHIC QUANTIFICATION FOR EFFECT OF EXCERCISE ON BLOOD FLOW IN BRACHIAL ARTERY** | |
|---|---|---|---|---|
| | **BEFORE EXCERCISE** | | **AFTER EXCERCISE** | |
| **Sr no** | **PI** | **DIAMETER [mm]** | **PI** | **DIAMETER [mm]** |
| **1** | 2.3 | 3 | 1.6 | 4 |
| **2** | 2.7 | 3 | 1.9 | 3.4 |
| **3** | 2.3 | 2.5 | 1.7 | 2.8 |
| **4** | 5 | 2.6 | 2 | 3.1 |
| **5** | 4 | 3.6 | 1.9 | 4 |
| **6** | 5 | 3.3 | 2.1 | 3.8 |
| **7** | 4.3 | 3.6 | 3.3 | 3.9 |
| **8** | 4.8 | 3.7 | 2.8 | 4.3 |
| **9** | 5.4 | 2.9 | 4.2 | 3.5 |
| **10** | 5.5 | 2.9 | 3 | 3.2 |
| **11** | 5.3 | 3 | 3.2 | 3.3 |
| **12** | 5.2 | 3 | 2.7 | 3.4 |
| **13** | 4.5 | 3.3 | 3.8 | 3.8 |
| **14** | 4.2 | 3 | 2.9 | 3.7 |
| **15** | 5.2 | 3 | 3.1 | 3.7 |
| **16** | 3.4 | 2.3 | 2.6 | 2.7 |
| **17** | 4 | 3.6 | 3.8 | 3.7 |
| **18** | 4 | 4 | 2.8 | 4.8 |
| **19** | 3.1 | 2.7 | 1.4 | 3.7 |
| **20** | 4 | 2.5 | 1.6 | 3.2 |

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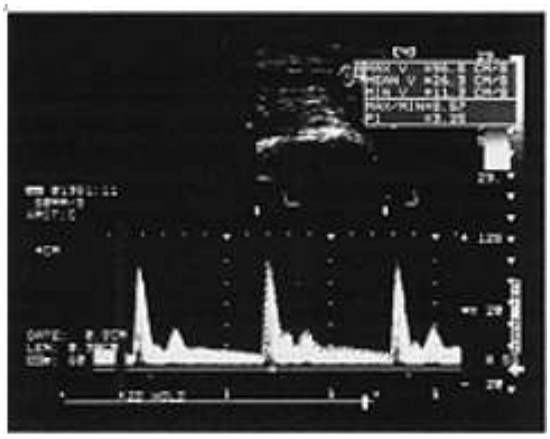

**Image 1:** Blood velocity in the brachial artery shown at rest

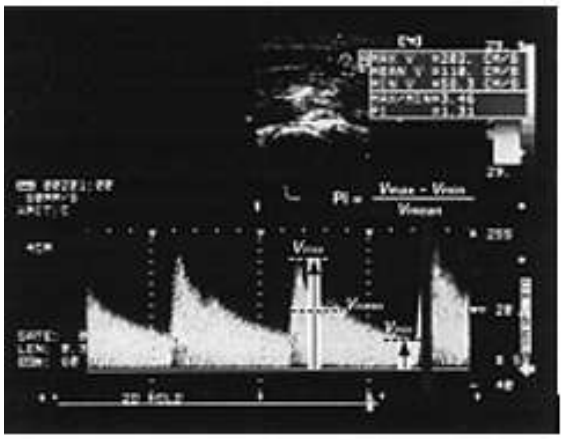

**Image 2:** Blood velocity in the brachial artery shown after the exercise

**Discussion**

The aim of the study was to quantify the effect of exercise on brachial artery in healthy individuals using vessel diameter and pulsatility index on doppler study

It is important for cardiovascular disease based arteriosclerosis to be effectively diagnosed for early intervention. This is especially important due to the increasing incidence of hypertensive diseases such as diabetes mellitus (Clarkson et al. 1996) and hypercholesterolemia (Celermajer et al. 1992; Vogel et al. 1996). Doppler ultrasound provides clinical information on several blood flow parameters including; changes in vessel diameter, blood velocity and pulsatility index (PI) determined by flow profiles (Taylor et al. 1985; Lewis et al. 1986; Clarkson et al. 1996; Kato 1998). Vascular reactivity assessed by the change in the PI has been used as a diagnostic tool for determining peripheral arterial stenosis in some previous clinical/basic science research studies of the cardiovascular system (Nomura et al. 1996; Perko et al. 1996; Kato 1998). In addition, the blood flow dynamics following the release of temporal arterial occlusion (AO) has been used as a model to reflect a limited oxygen supply to healthy active muscles (Osada et al. 2003).

In a clinical setting, the PI or blood velocity parameters are normally estimated under resting conditions, not in relation to exercise. Consequently, the time course of blood velocity and the PI in relation to exercise (exercise-induced ischemia due to a limited blood flow supply)

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may provide valuable information on peripheral vascular disease, which may not be observed under resting conditions.

The study by Hasan Ozcan et al(2006) examined the effects of incremental and submaximal exercise on structural and hemodynamic changes in the brachial artery flow parameters using Doppler ultrasonography. Twenty four healthy sedentary males (aged 19.54+/-0.59) performed submaximal (15 minutes heart rate to 75% maximal) and incremental (workload was increased 20W every 3 minutes until exhaustion) exercises by upper extremity ergometer. Before and after exercises the brachial artery diameter, peak systolic maximum velocity (Vmax), end-diastolic minimum velocity (Vmin) and time-averaged mean flow velocity (Vmean), volume blood flow and flow waveform patterns were recorded in a controlled environment. It was found that the diameter of the brachial artery, flow velocities, and blood flow increased significantly after each exercise protocol ($p < 0.001$). The Vmax ($p < 0.05$), Vmean ($p < 0.01$), and volume blood flow ($p < 0.01$) after the incremental exercise were significantly higher than those measured after the submaximal exercise but no significant differences were noted between the two exercise protocols when arterial diameters and Vmin were concerned. The flow pattern was monophasic in all subjects after incremental exercise. The flow pattern remained triphasic in two of the subjects after submaximal exercise. Blood flow velocities played important role in hemodynamic mechanism than conduit arterial diameter during arm exercises. Changes in conduit artery diameter did not significantly contribute to blood flow increase during high and moderate intensity exercises. There is minimal variation in waveform shapes of normal individuals after exercise. Therefore doppler ultrasonography proved a practical tool in the studies of the dynamic responses of blood flow and vascular resistance during rest and exercises.

The study by Osada et al (2004) examined the exercise-related time course of the PI in the brachial artery after ischemic or non-ischemic isometric handgrip exercise (IHE) using Doppler ultrasound, determined the potential use of this parameter as an indicator of vascular disease. Ten healthy young male subjects performed IHE at 10% and 30% of maximum voluntary contraction (MVC) for 2-minutes (min) with or without arterial occlusion (AO), or 2-min of AO alone. Following each 2-min session, PI was determined during the 5-min recovery period. A significant difference in the recovery PI was observed between IHE, ischemic IHE, as well as AO alone. Exercise with AO significantly increased the reduction in the PI compared to exercise alone, or AO alone, at both 10% and 30%MVC. These results suggest, exercise-induced changes in the time course of the PI during recovery may potentially be a useful diagnostic tool. Exercise-induced ischemic state may potentially be a useful indicator for detecting arteriovascular disease, even if it is not detected by AO alone. 10

The study by Dick HJ et al(2009)examined brachial artery(BA) blood flow and shear rate patterns during cycling, leg kicking, and walking exercise in 12 young subjects (24 +/- 3 yr). BA diameter, blood flow, and shear rate were assessed at baseline (1 min) and at three incremental intensity levels of cycling (60, 80, and 120 W), bilateral leg kicking (5, 7.5, and 10 kg), and walking (3, 4, and 5 km x h(-1)), performed for 3 min each. Edge detection and wall tracking of high-resolution B-mode arterial ultrasound images, combined with synchronized Doppler waveform envelope analysis, were used to calculate conduit artery

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diameter and anterograde/retrograde blood flow and shear rate continuously across the cardiac cycle.BA mean blood flow and shear rate increased significantly throughout each exercise protocol ($P < 0.001$), and BA anterograde blood flow and shear rate showed comparable increases throughout each protocol ($P < 0.001$). Retrograde blood flow and shear rate, however, demonstrated a significant increase during cycling and walking ($P < 0.001$) but not during leg kicking.

Shoemaker et al(1996) study data show that, for the six subjects tested, Doppler ultrasound measures of arterial MBV and diameter during both rest and exercise were reproducible and can be used as a reliable, noninvasive means of testing hypotheses pertaining to blood flow control.13

**Conclusion**

It was demonstrated that the reduced PI following exercise along with dilatation of the arterial diameter indicate vasodilator activity. This could potentially be an indice of arteriosclerosis not only at rest, but also following exercise. In future studies, exercise related changes in PI could be examined in patients with peripheral vascular disease.

**Footnotes**

No potential conflict of interest relevant to this article was reported.

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