Hemodynamic Changes After Static and Dynamic Exercises and Treadmill Stress Test; Different Patterns in Patients with Primary Benign Exertional Headache?

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Abstract- The pathophysiology of primary benign exertional headache (EH) is not still clearly defined. Some researchers have suggested an impaired vascular response as the etiology of this disorder. In this study we investigated whether there are any differences in blood pressure (BP) and heart rate (HR) of the subjects in course of the static and dynamic exercises and the treadmill stress test between those with and without EH. From university students, 22 patients with EH (mean age: 19.8±2.10, Female to Male: 7:15) and 20 normal subjects (mean age: 19.3±1.97, Female: Male: 8:12) were recruited. All the subjects performed the static and dynamic exercises at 30 and 20 percent of the maximal voluntary contraction (MVC) and Bruce treadmill stress test according to the standard protocols. HR and BP of all the cases at the baseline and during and immediately after each test were measured. No significant difference was found between the mean rise of HR, systolic and diastolic BP of the subjects with and without EH in static and dynamic exercises and also treadmill stress test. It seems that between those with and without EH, there is no significant difference in rise of HR and BP response to static and dynamic exercises and treadmill stress test. Further studies are required to find the pathophysiology and risk factors of EH.

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Keywords: Hemodynamic change; Exertional headache; Static exercise; Dynamic exercise

Introduction

Primary benign exertional headache (EH) as a mostly holocephalic and throbbing headache which is precipitated by any kind of exertion is no longer the deprived child of headache. This mostly transpired because of vulnerable contribution of researchers which recently their interest is much directed towards epidemiologic and clinical features of EH. Although no unified consensus on definition of exertional headache has been still reached by the experts (1,2), the most acceptable diagnostic criteria for EH is that proposed by the International Headache Society (IHS) in 2004 (code 4.3) (3). According to similar definitions, but not exactly the one addressed by IHS, some community based studies were conducted. These studies reported a wide range of 12.3%(4) to 30.4% (5) for the prevalence of EH. In contrast with Rook (6) and Pascual *et al.* (7) studies which reported a higher prevalence of EH among men, these epidemiologic studies (4,5) demonstrated a slight women preponderance. Furthermore, It was suggested that EH is more prevalent in early life and its incidence decreases by age (5).

Although some studies were conducted on epidemiologic aspects of EH, data on therapeutic interventions for treatment of EH are scarce. Currently, the therapeutic approaches to patients with EH are mostly on base of case reports and anecdotal findings (8,9). Triggers and precipitating factors and pathophysiology of EH are yet unknown that might be the reason for not finding the proper treatment for this condition. Therefore it seems recognizing the risk factors and mechanism of EH might help the researchers find the proper therapeutic interventions for prevention and treatment of EH.

Although the relation between headache and increased blood pressure (BP) is still under discussion (10,11), higher absolute and relative BP in those who develop headache during treadmill stress test comparing to normal subjects has been shown previously (12).

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Besides, Heckmann *et al.* (13) suggested an aberrant vasodilatation as the major pathology in patients with exertional headache. According to their theory, the vasodilatation in these patients would occur as a consequence of impaired myogenic cerebrovascular response. On this base we hypothesized that the blood pressure response in course of exertions is more exaggerated in patients with EH comparing to healthy controls. To our knowledge, hitherto, no study has compared the rise of systolic and diastolic BP during static and dynamic exercises and also tread-mill stress test between those with and without EH.

Materials and Methods

This comparative cross-sectional study included 22 patients with EH (EH group) and 20 subjects without EH (control group). The participants in this study were selected from the first year students of Tehran University of Medical Sciences. Using a self-administered questionnaire that was developed based on diagnostic ICHD-II criteria for EH (code 4.3) the students with EH were recognized. The questionnaire included basic demographic data, family history of systemic disease and any type of headache, headache profiles, aura manifestations, history of painkiller usage, severity of the headache and history of headache attributed to head and/or neck trauma (code 5). Two trained general practitioners interviewed all the subjects and did a physical examination of head and neck. Also, a brief neurological examination was included in order to rule out attribution of the headache to secondary disorders. To find the subjects of the control group, 20 students without EH were randomly selected from the first year students of the university. Subjects of both groups consented to participate in the study and thereby were invited to our center for more investigations.

In exercise laboratory of Sports Medicine Research Center, blood pressure and heart rate of the subjects were recorded in resting condition. Then, maximum voluntary contraction (MVC) of dominant hand of the subjects was recorded in kilograms using a calibrated hand dynamometer according to the manufacturer's instructions. A sports medicine physician as the supervisor of the procedure recorded the maximum of three consecutive readings for data analysis (14).

The static and dynamic exercises of the subjects were performed at 30% and 20% of MVC respectively. By placing a white strip on the dynamometer analogue output monitor, the required force for each subject was indicated. To perform the static exercise, the participants were required to squeeze the dynamometer with their dominant hand at 30% of MVC and hold it for 3 minutes (15). To perform the dynamic exercise, the participants were asked to squeeze the dynamometer with their dominant hand at 20% of MVC with the frequency of 20 contractions per minutes for 3 minutes. In this regard, the subjects were asked to squeeze and relieve the dynamometer with hearing each beep which was playing with the mentioned frequency from a CD. Both during (at 90^{th} second) and immediately after the test, the heart rate (HR) and blood pressure (BP) of the subjects were measured by a physician. In this regards, BP was measured on the non-exercising arm.

Afterward, all the patients underwent a treadmill stress test according to Bruce protocol. According to this preprogrammed protocol, at the first the subjects started the test at a slow 'warm-up' speed. Both the inclination and speed of the treadmill were increasing every 3 min. The subjects were required to continue the test until they were completely exhausted. The BP and HR of the subjects at the end of the test were recorded.

The subjects were asked to report their headache attacks either during or after the course of above exercises. Visual analogue scale (VAS) was used for measurement of the pain intensity in the subjects. In this regard, participants chose how much pain they had signifying a point on a 100 mm solid horizontal line which was confined by two smaller vertical lines. The left line indicated no pain; while the right line pointed out the most intense pain the patient can imagine.

In order to preserve blinding, the physician in the exercise laboratory was not aware of the group to which subjects were assigned. Outcome measurements of the study included the differences between the blood pressure and heart rate of the subjects both during and after the tests and their BP and HR in resting condition. After checking the normality of the data, independent sample t-test was used to compare the outcomes between the groups. Data were analyzed using SPSS 16 (SPSS Inc, Illinois, US). The results were considered as significant if the *P*-value was 0.05 or less.

This study was approved by ethical committee of Tehran University of Medical Sciences.

Results

In total, 42 subjects (27 female and 15 male) with the mean age of 19.5±2.03 years participated in the study. According to our findings the mean systolic and diastolic BP of the subjects was 115.8±12.40 and 67.9±8.64 mmHg respectively. We also found that the subjects had a mean HR of 83.9±10.57 beats/min. The mean MVC of the subjects was found to be 69.1±18.56 Kg.

Baseline characteristics of participants in each group are shown in Table 1. As it is demonstrated, there was no significant difference in resting HR and systolic and diastolic BP of subjects in EH and control groups.

Static exercise

No significant difference was found between the groups in the level of increase of both systolic BP and diastolic BP from the resting values either during or immediately after the static exercise test. Also, between the groups the mean increase of the HR of subjects from the resting position both during and immediately after the static exercise was not significantly different (Table 2).

Dynamic exercise

As with static exercise, comparing the groups, increase of systolic and diastolic BP and also HR of the subjects from the rest values during and immediately after the dynamic exercise was not statistically significant (Table 3).

Table 1. Baseline characteristics of the subjects participated in our study.

Variable	EH group (n=22)	Control Group (n=20)	*P* value
Age (year)	19.81 ± 2.10	19.30 ± 1.97	
Sex (M/F)	7/15	8/12	
Resting Heart Rate (beats/min)	84.36 ± 11.06	83.45 ± 10.27	0.78
Resting Systolic BP (mmHg)	115.09 ± 12.70	116.60 ± 12.34	0.69
Resting Diastolic BP (mmHg)	69.13 ± 6.81	66.60 ± 10.30	0.34
MVC (Kg)	70.09 ± 19.60	68.10 ± 17.78	0.73

Abbreviations: BP, Blood Pressure; MVC, Maximal Voluntary Contraction

Table 2. The mean increase of heart rate, systolic and diastolic blood pressure from resting position during and immediately after finishing the static exercise.

Time of Measurements		EH Group	Control Group	Mean Difference	*P*-value (95% Confidence Interval)
During Static Exercise	Heart Rate (beats/min)	9.68	11.80	-1.91	0.415 (-6.62 to 2.78)
	Systolic Blood Pressure (mmHg)	10.72	11.45	-0.72	0.80 (-6.45 to 5.01)
	Diastolic Blood Pressure (mmHg)	10.09	14.05	-3.95	0.79 (-8.39 to 0.47)
After Static Exercise	Heart Rate (beats/min)	11.68	17.20	5.51	0.134 (-12.80 to 1.76)
	Systolic Blood Pressure (mmHg)	17.09	17.80	0.709	834 (-7.50 to 6.08)
	Diastolic Blood Pressure (mmHg)	14.59	16.95	2.35	0.436 (-8.42 to 3.70)

Table 3. The mean increase of heart rate, systolic and diastolic blood pressure from resting position during and immediately after finishing the dynamic exercise.

Time of Measurements		EH Group	Control Group	Mean Difference	*P*-value (95% Confidence Interval)
During Dynamic Exercise	Heart Rate (beats/min)	4.86	7.45	-2.58	0.351 (-8.78 to 3.74)
	Systolic Blood Pressure (mmHg)	4.68	7.20	-2.51	0.421 (-6.45 to 5.01)
	Diastolic Blood Pressure (mmHg)	10.13	7.95	2.18	0.685 (-8.63 to 13.01)
After Dynamic Exercise	Heart Rate (beats/min)	7.09	6.25	0.840	0.725 (-3.95 to 5.63)
	Systolic Blood Pressure (mmHg)	3.72	5.30	-1.57	0.612 (-7.78 to 4.64)
	Diastolic Blood Pressure (mmHg)	5.90	6.60	-0.69	0.741 (-4.88 to 3.50)

Table 4. Comparison between the mean increase of heart rate, systolic and diastolic blood pressure from resting position immediately after finishing the treadmill stress test.

Variable	EH Group	Control Group	Mean Difference	*P*-value (95% Confidence Interval)
Heart Rate (beats/min)	99.95	93.40	6.55	0.354 (-7.56 to 20.67)
Systolic Blood Pressure (mmHg)	45.09	45.10	-0.009	0.99 (-11.11 to 11.09)
Diastolic Blood Pressure (mmHg)	9.04	9.55	-0.504	0.896 (-8.28 to 7.27)

Treadmill stress test

Comparing the increasing rate of systolic and diastolic blood pressure of the subjects at the end of treadmill stress test in EH group with those in control group, no significant relation was found. As with BP, in comparison to the control group the increase of the HR of the subjects in EH group was not significant (Table 4).

Of 22 cases in the EH group, during the treadmill stress test, 17 subjects presented a pulsating headache. The mean pain intensity of the subjects in EH group was 2.8±2.14 (range: 0 to 7) using VAS.

Discussion

The present study compared the response of BP and HR of subjects with exertional headache during and immediately after static and dynamic exercises and treadmill stress test with control subjects. The results of the study showed no significant difference in BP and HR of the subjects with EH compared with controls after dynamic and static tests. These findings are in contrast with previous assumptions that hemodynamic changes such as dramatic elevation of blood pressure and increase of heart rate as a consequence of vascular dysfunction lead to precipitation of the headache during or after strenuous physical activity in those with EH (13,16).

Several authors have previously assumed an association between sexual activity related headache (SH) and EH (7,17). In the study carried out by Evers *et al.* (18), it was shown that there is no difference in hemodynamic response of patients with sexual headache and control subjects. It seems the results of the current study regarding the hemodynamic response of subjects with EH to preprogrammed exercises are in concordance with those published for SH. This might put more emphasis on the hypothesis which EH and SH have similar underlying pathophysiologies.

The treadmill stress test is previously recommended as a good setting for the investigation of the possible association between BP rise and the development of headache (12). In this study, no significant relation was found between the increasing values of systolic and diastolic BP in EH and control groups. These results are in contrast with Thomaides *et al.* (12) study that reported a higher absolute and relative diastolic blood pressure in those who presented headache during the treadmill stress test compared with those who did not. In this study of 22 cases in the EH group, during the treadmill stress test, 17 subjects presented a pulsating headache. However, as it was predicted by the researchers, none of the subjects of the control group presented headache during the treadmill stress test.

Pathophysiology of EH which has been recognized for decades and is coded as a separate entity in HIS (3) is still not understood. It is previously reported that arterial blood pressure of the weight lifters during their exertion reaches to more than 300 mm Hg (19). On this base it was postulated that exertional headache might be because of increased arterial BP in course of resistance exercises (20). Angiographic finding of arterial spasm in those with EH (21) along with migrainous nature of EH (20,22) led to more implication that EH has a vascular basis. In this study the hemodynamic response of the patients with EH and control subjects after 3 different exertional tasks were compared and no significant difference was found between the groups. It can be suggested that hemodynamic response of subjects with and without EH after heavy resistance trainings should be compared in future studies. Weight lifters who according to anecdotal findings have a relatively high rate of EH (20,23) can be considered as the target sample by the researchers for their future studies.

As it is mentioned before, the participants in this study were selected from the first year students of the university. Considering the role of age in prevalence of EH, recruitment of subjects with different age groups could be a more rational design for this study. As another limitation, the intensity of the static and dynamic exercises that were used in this study was low or medium. Therefore, comparison between hemodynamic changes of the patients with EH and controls in course of high intensity exercises can be investigated in further studies.

In conclusion, it seems that between those with and without EH, there is no significant difference in HR and BP response to static and dynamic exercises and treadmill stress test. Comparing the hemodynamic response of subjects with EH with healthy subjects in course of heavier resistance exercises might be helpful in elucidation of some dark aspects of underlying pathophysiology of EH as a separate entity in IHS classification.

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