Efficacy of isometric exercise full knee extension horizontally (FKEH) - a new and simple maneuver to predict early onset of hypertension

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ABSTRACT

Hypertension is recognized as one of the risk factors for cardiovascular mortality and morbidity. Early identification of persons at increased risk for developing hypertension is a priority, which help them, to live a healthy life by altering lifestyle. Persons having predisposing factors of hypertension (e.g., family history of hypertension) show blood pressure hyper-responsiveness to stress. Elevated blood pressure due to sympathetic stimulation prevailed longer time in susceptible persons. In previous studies some instruments (e.g., hand immersion in cold (4°C) water or isometric exercise by handgrip dynamometer) were required to elicit sympathetic stimulation. In the present study a simple maneuver Full Knee Extension Horizontally (FKEH) has been introduced - a stressor that caused full isometric contraction of quadriceps femoris muscles of both sides. The test was conducted in normotensive, non-smoker males (n=150) of age group 18-25 years. Among them some (n=100) were from families having no history of familial hypertension and others (n=50) were from the families with history of hypertension. The causal blood pressure and heart rate of the participants were recorded. Then the volunteers were requested to perform FKEH maneuver for one minute. Both blood pressure and heart rate were recorded immediately after and 3 minutes following FKEH. The data analyzed using t-test showed that, diastolic blood pressure didn't return and stabilized to pre-exercise level even after 3 minutes following FKEH in volunteers who were mostly from hypertensive family ($P<0.05$) i.e., having predisposing factors of hypertension. This indicated those people are prone to early onset of hypertension as their Autonomic Nervous System (ANS) is not competent enough to stabilize their blood pressure to pre-exercise level. Hence, stress in the form of FKEH for one minute may be used as a bedside test to assess the competence of ANS and the proneness of developing early hypertension.

Keywords: Full Knee Extension Horizontally, Isometric exercise, Hypertension

INTRODUCTION

Stress is a condition that disrupts or threatens to disrupt homeostasis. Stress may be physical or mental. Physical stress includes exercise (isometric or isotonic), pain, temperature (too hot or cold) etc. Stress is associated with liberation of glucocorticoids and catecholamines along with other hormones.

Cardiovascular reactivity to stress may have a pathological role in neurogenic hypertension. People who are at risk for elevated blood pressure might have exaggerated stress induced cardiovascular responses at a younger age.[1]

Hypertension is recognized as one of the risk factor for cardiovascular mortality and morbidity.[2] Hence identification of persons at increased risk for developing hypertension is a priority. Early detection of proneness to hypertension may help an individual to live a healthy life by altering lifestyle (e.g., avoidance of alcoholic drinks, smoking, excessive fatty food intake etc and adoption of the practice of yogic exercise[3], moderate aerobic exercise [4], mental relaxation[5] and so on.

Once stimulated by stressor, sympathetic system causes rise in heart rate (HR) and blood pressure (BP) but they return and stabilize to normal level within very short period of time after withdrawal of stressor.[6] Elevated BP and HR prevail for longer time in susceptible individual. Naturally, person exhibiting higher cardio - vascular reactivity to a stressor and lower rate of recovery after withdrawal of stressor that cause sympathetic stimulation are at high risk for developing early onset of hypertension.

Previous studies indicated that sympathetic stimulation caused by stress (e.g., hand immersion in cold (4°C) water, or isometric exercise by handgrip dynamometer) [7] resulted increase in BP[7,8] which decreased and stabilized to causal BP that prevailed before exercise within few minutes after the completion of exercise. In all those cases some instruments were required to elicit sympathetic stimulation. This inspired us to think whether we can elicit the same without using any instrument. Thus, Full Knee Extension Horizontally (FKEH) a maneuver for isometric exercise was adopted which can evoke sympathetic stimulation for the evaluation of autonomic function and to detect susceptible individual to make them aware so that they can avoid cardiovascular accidents (viz.hypertension) in future by taking proper precautionary measures.

Table-1: Baseline, stress and recovery heart rate and blood pressure in volunteers from hypertensive families

Volunteers from hypertensive family	Conditions	HR (Mean±SD)	SBP (Mean±SD)	DBP (Mean±SD)
A) n = 35	Baseline	73.17 ± 1.42	115.08 ± 3.15	74.28 ± 2.23
	Immediately after 1 minute	78.14 ± 2.42*	120.80 ± 3.47*	79.60 ± 2.90*
	Recovery	73.40 ± 1.80	115.25 ± 3.53	74.45 ± 2.70
B) n = 15	Baseline	74.06 ± 1.33	117.46 ± 2.66	75.06 ± 3.45
	Immediately after 1 minute	80.93 ± 2.87*	124.67 ± 3.75*	82.00 ± 3.54*
	Recovery	74.40 ± 1.84	118.0 ± 3.02	80.13 ± 3.06*

Fig. 1. Knee extension exercise (isometric contraction of quadriceps femoris) by a volunteer.

MATERIALS AND METHODS

Normotensive, non -smoker sedentary male subjects (n=150) of age group 18-25 years participated in the study as volunteers. Among them (n=100) were from families having no history of familial hypertension and others (n=50) were from families with history of hypertension.

The volunteers were requested to abstain from beverages like tea, coffee for preferably 12 hours and strenuous physical activity and alcohol for at least a day prior to maneuver. The experiment was done at 10-11 AM in the month of October-December and the room temperature was maintained at 20-22°C.

Blood pressure was measured in the sitting position by using mercury sphygmomanometer and stethoscope. The causal blood pressure and heart rate of the normotensive participants were recorded after allowing them to take rest for five minutes.[9] Then the volunteers were requested to do full knee extension horizontally for one minute (Fig. 1). Systolic blood pressure was noted at the point where Korotkoff sound became audible and diastolic blood pressure was also noted at the point at where the sound muffled.[9,10]

Both blood pressure and heart rate were recorded respectively after one minute and three minutes (when the volunteers relaxed their quadriceps as per instruction). During the maneuver, participants were requested to respire normally.

RESULTS

The result has been presented in Table-1 and 2. From the tables it is evident that FKEH maneuver for a minute caused rise of heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP). A few volunteers (5%) with no family history of hypertension showed elevated DBP even after 3 minutes following FKEH. On the other hand, more number of volunteers from hypertensive family (30%) showed elevated DBP which did not return to baseline and stabilize following the aforesaid experimental condition, even after 3 minutes ($P<0.05$).

DISCUSSION

- FKEH (Full Knee Extension Horizontally) was carried out by the young male volunteers (age=22 ±1 yr) only. Age matched females were excluded because during child bearing age, estrogenic effect prevails in them; as well as they have lower autonomic support of arterial BP and lesser effective baroreflex buffering than men.[11]
- FKEH was done for a minute, BP and HR were measured immediately; then the same parameters were recorded again after 3 minutes. FKEH cause withdrawal of vagal tone activation of sympathetic nervous system, release of catecholamines from nerves (norepinephrine) and adrenal gland (norepinephrine, epinephrine). Catecholamines have half life of about 2 minutes in circulation.[12]

Table-2: Baseline, stress and recovery heart rate and blood pressure in volunteers from normotensive families

Volunteers from normotensive family	Conditions	HR (Mean±SD)	SBP (Mean±SD)	DBP (Mean±SD)
A) n = 95	Baseline	71.62 ± 2.95	113.81 ± 5.07	72.02 ± 3.08
	Immediately after 1 minute	76.94 ± 3.34*	118.77 ± 4.47*	77.15 ± 2.96*
	Recovery	71.81 ± 3.02	113.87 ± 4.58	72.06 ± 3.06
B) n = 5	Baseline	74.20 ± 3.03	114.80 ± 2.28	74.00 ± 2.00
	Immediately after 1 minute	80.60 ± 3.78*	120.00 ± 2.82*	80.80 ± 2.28*
	Recovery	74.40 ± 1.81	116.00 ± 3.16	78.40 ± 1.67*

*P<0.05, HR= Heart rate, SBP=Systolic blood pressure, DBP= Diastolic blood pressure

Thus slight changes in NE beyond its physiological concentration cause rise in BP for 1-3 minutes until it get destroyed.[13] Naturally person having good autonomic control could bring down and stabilize blood pressure to pre-exercise state quickly (about 3 minutes after the stressor/FKEH for 1 minute).

- Isometric exercise FKEH might cause sympathetic stimulation by two ways – a pressor reflex originating in contractile muscle.[14,15] This reflex originates in sensory receptors which are sensitive to ischemic metabolites generated during muscular contraction. The second mechanism for increment in sympathetic outflow is activation of cardiovascular centers by descending central neural pathways involved in the initiation of somatomotor activity.[16,17]
- Sympathetic nor-adrenergic fibers are vasoconstrictor in function. Nor-adrenergic postganglionic sympathetic nerves also contain neuropeptide Y – a vasoconstrictor. Vasoconstrictor discharge is associated with increased arteriolar constriction and rise of BP. Impulses in nor-adrenergic sympathetic nerves results in an increase in HR and force of cardiac contraction.[18,19]

More number of volunteers from hypertensive family (30%) showed elevated diastolic blood pressure even after 3 minutes following FKEH. This is in accordance with the observation of Kotchen - "Family studies controlling for a common environment indicate the blood pressure heritability are in the range of 15-35%. In twin studies, heritability estimates of blood pressure are ~ 60%, for males.[20] Quick stabilization of DBP to the baseline or even below (i.e., within 3 minutes) – indicated competent vagal activation through baroreflex and the normal sympathetic discharge to the peripheral blood vessels. On the contrary, persistence of diastolic blood pressure at a higher level for longer time indicated either the incompetent vagal stimulation or overactive sympathetic system resulting in peripheral arteriolar constriction through liberation of more catecholamines from nerves and from adrenal medulla.[12] It might also be due to stimulation of muscle chemoreflex which is a potent stimulus for activation of sympathetic nerve activity to muscles in human[11] or might be due to less production of nitric oxide from endothelium of blood vessels.[21]

A few of the volunteers (5%) with no family history of hypertension showed rise in DBP even after 3 minutes following FKEH, which might be due to gene expression for hypertension, dysfunctions of Autonomic Nervous System (ANS), less Nitric Oxide release from vascular endothelium or less physical activity in those volunteers.

Persons who showed higher cardiovascular reactivity to a stressor FKEH and slower rate of recovery after the withdrawal of the stressor that cause sympathetic stimulation indicated that their autonomic control system is not competent enough to stabilize the BP to pre-exercise state quickly. Naturally, they are at high risk of early onset of hypertension.

Results of previous and present study indicated – stress in the form of FKEH for a minute (isometric exercise) might be used as a stressor to stimulate sympathetic nervous system instead of stimulating SNS by using handgrip dynamometer for a minute (isometric exercise) to assess the competence of ANS at bedside, which in turn can detect the young males prone to early onset of hypertension.

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