CARDIOVASCULAR RESPONSES TO TREADMILL EXERCISE TESTING IN ANEMIA

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Manuscript received: November 19,1996; Initial review completed: January 20,1997; Revision accepted: February 26,1997

Objective: *To study exercise performance on a treadmill in anemic children.* ***Design:*** *Prospective case control study.* ***Setting:*** *Department of Pediatrics and Intensive Care Unit, Department of Medicine, King George's Medical College, Lucknow.* ***Subjects****: The study population consisted of 41 cases of anemia (10 mild, 21 moderate and 10 severe) and 11 normal age and height matched children aged between 7-12 years.* ***Methods****: These subjects were exercise tested on Quinton Model Q5000 treadmill using Modified Naughton Q5000 protocol. Heart rate, systolic blood pressure, double product, ECG changes, exercise duration and metabolic equivalents achieved during peak exercise were studied. Statistical analysis was performed using analysis of variance (ANOVA) test.* ***Results****: No significant difference was observed in values of resting heart rate, heart rate at peak exercise, recovery heart rate, blood pressure response, resting double product, double product at peak exercise, recovery double product and ECG changes in any of the study groups ($p > 0.05$). However, the gain in heart rate at peak exercise compared to basal value, and double product, total exercise duration and metabolic equivalent (MET) values at peak exercise were significantly low in anemic children on comparison to normal controls ($p < 0.001$).* ***Conclusions:*** *Cardiovascular responses are blunted in anemia, mainly because of depleted cardiac reserve.*

Key **words:** *Anemia, Treadmill testing, Cardiovascular responses.*

EXERCISE testing elicits the body reaction to measured increases in acute exercise. The changes in heart rate, blood pressure, respiration and perceived level of exertion provide data that permit quantitative estimation of cardiovascular functioning and conditioning (1). The treadmill has been widely used in the testing of exercise fitness since only the ability to walk is required, numerous gradations of exercise level can be achieved and extensive standards have been developed.

Different studies have reported the high incidence of anemia in young children in India(2). Anemia has a negative impact on physical work capacity in different age groups as measured by changes in maximal oxygen uptake and other metabolic parameters(3-5).

Few studies have been done on exercise tolerance in normal children on treadmill, in western countries and occasional ones in India (6-8). In anemic children, no study on treadmill has been done in India, to the Best of our knowledge. Such data will be useful in assessing cardiovascular functioning in normal as well as anemic children. It will also serve a useful parameter to assess

fitness of children taking part in competitive sports. The present study was, therefore conducted to evaluate exercise performance in anemic and normal school going children.

Subjects and Methods

The present study was conducted on 41 anemic children (irrespective of cause), aged between 7-12 years, either admitted in the Pediatrics Ward of King George's Medical College, Lucknow or attending the Out Patient Department of Pediatrics or those studying in various schools of Lucknow. Eleven normal age and height matched school children were also evaluated.

This study population was subjected to detailed history and relevant general and systemic examinations. Nutritional status of the children was assessed based on the IAP classification of nutritional status. Body surface area was calculated from standard nomogram using weight and height. The diagnosis of anemia was made by clinical assessment and hemoglobin estimation by cyanmethaemoglobin method. A cut off criteria for diagnosis of anemia was taken as hemoglobin level less than 12 g/dl(9). Children were classified for severity of anemia as follows: (i) Mild - 10-12g/dl; *(ii)* Moderate - 7-9.9g/dl; and *(iii)* Severe - <7g/dl. Children having problems like rheumatic and congenital heart disease, hypertension, bronchial asthma, physical handicap, mental sub normality and acute febrile illness were excluded from the present study.

These subjects were then exercise tested on Quinton Model Q5000 Treadmill in the Intensive Care Unit, Department of Medicine, King George's Medical College, Lucknow. After 12 hours of rest in the night, the subjects were prepared for exercise testing, including loose fitting dress, informed consent from guardians and skin preparation for electrodes with gentle rubbing with spirit gauze. Disposable Nikomed electrodes were used for each testing. A 10 leads electrode system was attached in appropriate position and the procedure was explained and demonstrated to the subjects, specially regarding most comfortable gait and safety devices. Subjects were instructed not to tightly grasp the side rails to avoid dissipation of work forces, decreasing VO_2 and work, while increasing exercise time. The protocol for exercise testing has been depicted in *Table I.* The following parameters were measured and studied: (*i*) Heart rate (HR); *(ii)* Blood pressure (BP); *(iii)* Double product (HR x BP); *(iv)* Exercise duration; *(v)* Metabolic equivalents (METS); and *(vi)* ECG changes. The end point of the test was refusal by the child to exercise further on account of fatigue (maximal test). Arterial blood gas monitoring was not done as we lacked technical facilities for the same in our tread mill testing laboratory. Statistical analysis was done by analysis of variance (ANOVA) test.

Result

The baseline data including age,

TABLE I-*Treadmill Protocol-Naughton Q5000*

Stage	Speed (miles/h)	Grade (%)	Duration (min:sec)	METS
Rest/ Record	1.0	0.0	-	1.8
1	1.0	0.0	2:00	1.8
2	2.0	0.0	2:00	2.5
3	2.0	3.5	2:00	3.4
4	2.0	7.0	2:00	4.4
5	2.0	10.5	2:00	5.3
6	2.0	14.0	2:00	6.3
7	2.0	17.5	2:00	7.3

METS - Metabolic equivalents.

weight, height and body surface area of 52 (45 male, 7 female) studied subjects are depicted in *Table II.* Subjects were also matched for age and height with each other, but body weight and body surface area differed in these subjects significantly. Out of 41 anemic cases, 34 were due to nutritional causes. Seven were due to other causes (hypoplastic anemia and acute myeloid leukemia), but in these patients also, nutritional factors of causation were present. No other deficiency disorders could be detected in cases.

The results of treadmill testing on the subjects are summarized in *Table III.* There was no significant difference in resting heart rate and peak heart rate values in the four groups but the gain in heart rate at peak exercise was significant (p=0.001). Blood pressure response did not reveal a significant difference in any of the groups. Double product response to graded treadmill exercise was similar to heart rate response with a significant gain during peak exercise in normal children compared to anemic children ($p < 0.001$).

The control group exercised for significantly more duration (13.2 ± 1.16 min) than mild, moderate and severely anemic children who exercised for 8.57 ± 0.48, 7.57 ± 1.44 and 3.25 ± 1.30 min, respectively ($p < 0.001$). The value of metabolic equivalents (METS) achieved during peak exercise was significantly higher in normal children compared to anemic groups according to severity of anemia ($p < 0.001$). No significant ECG change was observed in any of the subjects on maximal exercise. All subjects maintained sinus rhythm and none had ST segment depression more than 1 mm in lead V_5. An analysis of exercise performance was done according to body surface area. For this analysis, subjects were divided in 3 groups according to BSA, irrespective of hemoglobin status. The analysis revealed that no parameters differed significantly in any of the groups except for exercise duration. Children having BSA >1.0 m^2 exercised for longer time cornpared to ones having BSA <0.9 m^2 with intermediate value in those having BSA between 0.9-1.0 m^2 (p=0.035). It is possible that to a small degree, low BSA may be the factor in altered cardiovascular response (less exercise duration). But the level of statistical significance was much higher, when these responses were analyzed with degree of anemia, thereby implying that it is anemia which is the major contributor to the altered cardiovascular responses.

TABLE II-*Baseline Data (Mean ± SD) of Study Subjects*

	Controls (n=ll)	Anemia			p value
		Mild (n=10)	Moderate (n=21)	Severe (n=10)	
Age (years)	9.5±1.50	9.0±1.63	9.8±1.46	9.65±1.82	> 0.05
Weight (kg)	28.18±4.38	24.20±4.24	25.90±2.30	22.55+4.95	0.008
Height (cm)	128.5±7.89	123.6±9.07	127.76±9.08	127.10±7.98	>0.05
Body surface area (m^2)	0.96±0.08	0.86±0.11	0.97±0.05	0.85±0.11	0.008

TABLE III— *Values of Selected Parameters During Graded Treadmill Exercise in Controls and Cases*

	Controls (n=ll)	Mild anemia (n=10)	Moderate anemia (n=21)	Severe anemia (n=10)
Heart Rate (per minute)				
Resting Heart rate (HR)	157.64 ±0.25	110.25 ±13.47	106.62 ±14.64	112.80 ±17.32
Peak Heart rate	157.64 ±21.61	151.00 ±8.39	148.05 ±14.57	146.20 ±21.98
Gain in HR* at peak exercise	58.99 ±20.21	37.78 ±13.92	41.01 ±17.07	28.46 ±9.42
1 minute recovery	114.73 ±16.24	117.90 ±15.30	116.86 ±16.64	121.00 ±27.24
Systolic Blood Pressure (mm Hg)				
Resting BP	102.36 ±10.31	105.20 ±7.25	104.76 ±6.24	107.80 ±6.49
BP at peak exercise	114.36 ±8.19	117.00 +7.22	117.43 ±4.95	115.40 ±6.54
Gain in BP at peak exercise	12.00 ±5.29	11.80 ±3.45	11.61 +5.23	7.60 ±2.79
Recovery (lmin)	109.29 ±8.16	113.83 ±6.70	110.57 ±4.11	112.20 ±5.85
Double Product (DP) (in beats mm Hg)				
Resting DP	10.47 ±2.96	11.78 ±2.13	11.27 ±2.13	12.57 ±2.70
DP at peak exercise	18.14 ±3.28	17.68 ±1.64	17.19 ±1.90	16.90 ±3.34
Gain in DP at peak exercise**	7.69 ±0.95	5.95 ±0.99	5.92 ±1.90	4.33 ±1.66
Recovery (lmin)	12.04 ±1.65	13.16 ±2.16	12.76 ±2.20	14.84 ±3.57
Exercise duration** (minutes)	13.24 ±1.16	8.57 ±0.48	7.57 ±1.44	3.25 ±1.30
METS Achieved**	6.84 ±0.52	4.85 ±0.47	4.37 ±0.73	2.29 ±0.33

*- p= 0.001; **- p <0.001

Discussion

In the present study, 41 children with anemia and 11 healthy controls were subjected to treadmill exercise testing to quantiate cardiovascular effects of anemia. Symptom limited maximal exercise test was done as it is more informative study than the cardiovascular responses to exercise(6,7).

Heart rate response in anemic children in the present study was found to be less than controls, *i.e.,* the gain in heart rate at peak exercise was significantly less in anemic children but the recovery time for heart rate was prolonged in anemic children. These findings can be explained on the basis of cardiac reserve which is already depleted in anemic children, which results in higher resting heart rate, less gain in heart rate at peak exercise and prolonged recovery time. The blood pressure response to exercise in anemic children was similar to that occurring in healthy subjects in the present as well as an earlier study(l0).

Myocardial oxygen uptake reflecting myocardial oxygen consumption, can be estimated during exercise testing by the product of heart rate and systolic blood pressure, *i.e.,* double product, also called modified tension time index. The index in the present study behaved similar to the heart rate response, *i.e.,* at peak exercise, the gain in double product was significantly less in anemia than in healthy children. These findings can again be explained by the depleted cardiac reserve in anemic children. We also observed that the reduced gain in double product in peak exercise was related to degree of anemia. To the best of our knowledge, this kind of correlation has not been reported in the literature earlier.

We did not find any evidence of electrical instability during exercise or recovery in children with anemia indicating that in presence of anemia with normal heart, exercise does not produce myocardial ischemia implying that these subjects may not be restricted for outdoor activities. Alpert *et al*.(10) also found no electrical instability in their study in anemic children.

We also analyzed metabolic equivalent (MET) which is a unit of oxygen uptake (3.5 ml O_2/kg/min). In the present study we found that anemic children achieved significantly less METS as compared to controls. This parameter also correlated directly to the degree of anemia. The lower degree of METS achieved in anemic children may be related to skeletal muscle exhaustion rather than reduced cardiac reserve, as also evidenced by decreased exercise duration in anemic children. Similar results, although with different methodology were also reported by other authors(5,ll,12). A detailed work of such nature has not been reported in children or adults in the literature.

It is concluded that cardiovascular responses are blunted in anemia, mainly because of depleted cardiac reserve.

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