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Normal Values of Echocardiography in Pediatric Age Groups II. Per Cent Fractional Shortening of the Left Ventricular Dimension and Mean Velocity of Circumferential Fibre Shortening

The Shimane Heart Study

(echocardiography/%⊿ LVD/mean Vcf)

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Per cent fractional shortening of left ventricular internal dimension (%⊿LVD) and mean velocity of circumferential fibre shortening (mean Vcf) were determined by means of echocardiography in 328 healthy Japanese children of school age (179 males and 149 females). %⊿LVD was independent of body surface area and heart rate. Mean Vcf was inversely related to body surface area and directly related to heart rate. These data and relationships obtained were consistent with those obtained from non-Japanese adults and children.

Per cent fractional shortening of the left ventricular dimension (%⊿LVD) and mean velocity of circumferential fibre shortening (mean Vcf) are well-known indices of cardiac performance and are determined by means of either echocardiography or angiocardiography. We analyzed echocardiographic recordings of normal children of school age and determined these indices from them. We report herein the echocardiographically determined %⊿LVD and mean Vcf.

MATERIALS AND METHODS

The subjects were obtained through mass screening examination of Japanese children, an outline of which was described on the previous report (1). The numbers of subjects available to determine %⊿LVD and mean Vcf are listed on Table I. These do not include children with organic heart disease or those who have had heart surgery.

Echocardiographic examinations were performed using Aloka UST-2161B (3.5MHz) and UST-2155 (2.25 MHz) transducers, Fukuda Denshi SSD-110S ultrasonoscope, and ECO-125S recorder. Paper speed for recording was

The following abbreviations are used : %⊿LVD, per cent fractional shortening of left ventricular dimension ; mean Vcf, mean velocity of circumferential fibre shortening ; LVIDd, left ventricular internal dimension at end diastole ; LVIDs, left ventricular internal dimension at end systole ; LVET, left ventricular ejection time ; BSA, body surface area ; HR, heart rate.

TABLE I. *Number of Subjects*

Age (yrs)	Males	Females
6– 7	81	49
9–10	54	53
12–15	44	47
Total	179	149

usually 50 mm/sec.

Left ventricular internal dimensions at end diastole (LVIDd) and at end systole (LVIDs), and left ventricular ejection time (LVET) were measured on standard left ventricular echocardiographic recordings. As shown on Fig. 1, LVIDd was measured at the peak of R wave of electrocardiogram simultaneously recorded, LVIDs was measured at the maximal anterior movement of the left ventricular posterior wall, both as the distance between the endocardial surface echoes (the method of Fortuin *et al.* (2, 3)). LVET was from the onset of anterior movement of left ventricular posterior wall to its maximal anterior movement. In addition, R-R interval was measured on the electrocardiogram at the same cardiac cycle where measurements above were performed.

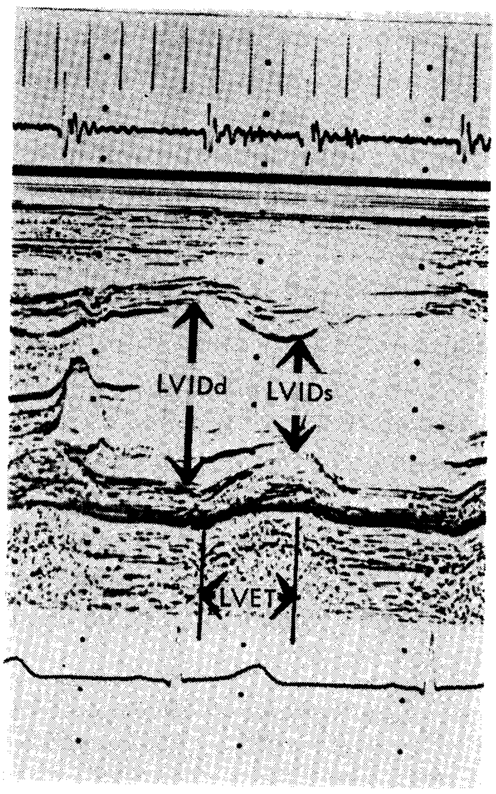


Fig. 1. An example of standard left ventricular echocardiogram. Landmarks for the measurement of LVIDd, LVIDs, and LVET are displayed.

Echocardiographic $\%\Delta LVD$ and mean Vcf were calculated from the formulae ;

$$\%\Delta LVD\ (\%) = \frac{LVIDd - LVIDs}{LVIDd} \times 100$$

$$\text{mean Vcf (circ/sec)} = \frac{LVIDd - LVIDs}{LVIDd \times LVET} = \frac{\%\Delta LVD}{LVET \times 100}$$

(unit of LVET : second).

Body surface areas were estimated from body weight and height using nomogram (4) ; heart rates were calculated from electrocardiographic R-R intervals.

RESULTS

$\%\Delta LVD$ and mean Vcf in males and females of various groups are listed on Table II. These figures were consistent with the data obtained by other authors.

There was no significant difference in $\%\Delta LVD$ among these groups, implying that this index is not dependent on age. On the other hand, mean Vcf was relatively small in higher age groups. This finding reflects the inverse relationship of mean Vcf with heart rate as is described later. Virtually no significant difference between the sexes was noted in either index.

TABLE II. *%ΔLVD and Mean Vcf in Various Groups*

Age (yrs)	Sex	%ΔLVD (percent) Mean	S. D.	Mean Vcf (circ/sec) Mean	S. D.
6– 7	Male	35.6	4.7	1.33	0.23
	Female	34.6	4.1	1.29	0.23
9–10	Male	36.3	4.2	1.32	0.19
	Female	35.8	5.3	1.31	0.23
12–15	Male	35.4	5.3	1.23	0.22
	Female	36.3	5.2	1.22	0.18

The interrelationships of $\%\Delta LVD$ and mean Vcf with body surface area and heart rate are demonstrated on Figs. 2, 3, 4, 5. In each plotting, distributions of these indices throughout the entire range of BSA and HR were warranted to be homoscedastic.

$\%\Delta LVD$'s correlated poorly with either body surface area or heart rate, and remained constant within a considerably narrow range. Mean Vcf, on the contrary, showed a statistically significant correlation with these variables, direct relationship with heart rate and inverse relationship with body surface area, and relatively wide range of scattering. The dependence of mean Vcf on heart rate was reported by other authors as well (5, 6). LVET

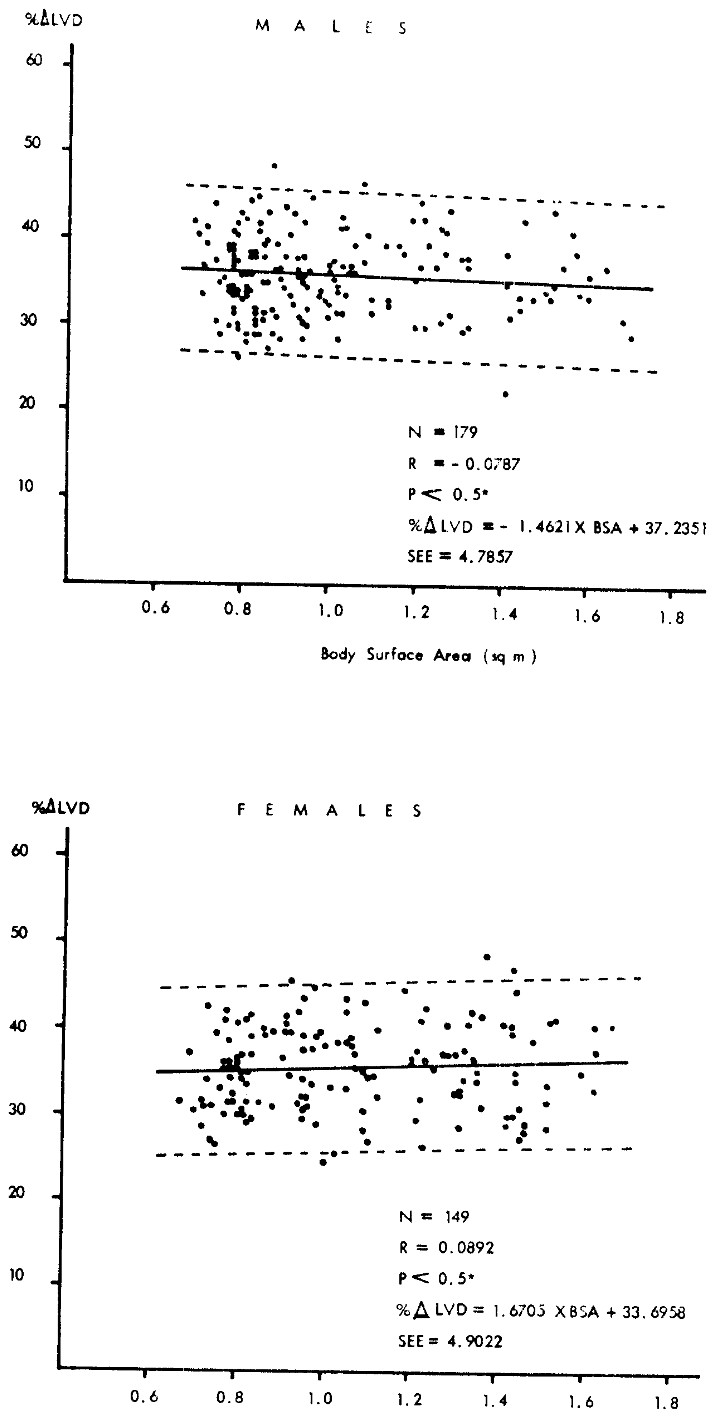


Fig. 2. Plottings of %ΔLVD against body surface area (BSA) in males and females. The poor correlation between %ΔLVD and BSA, suggests the independence of %ΔLVD of BSA. Solid line, regression line ; broken lines, twice the standard error above and below the regression line. *Not significant.

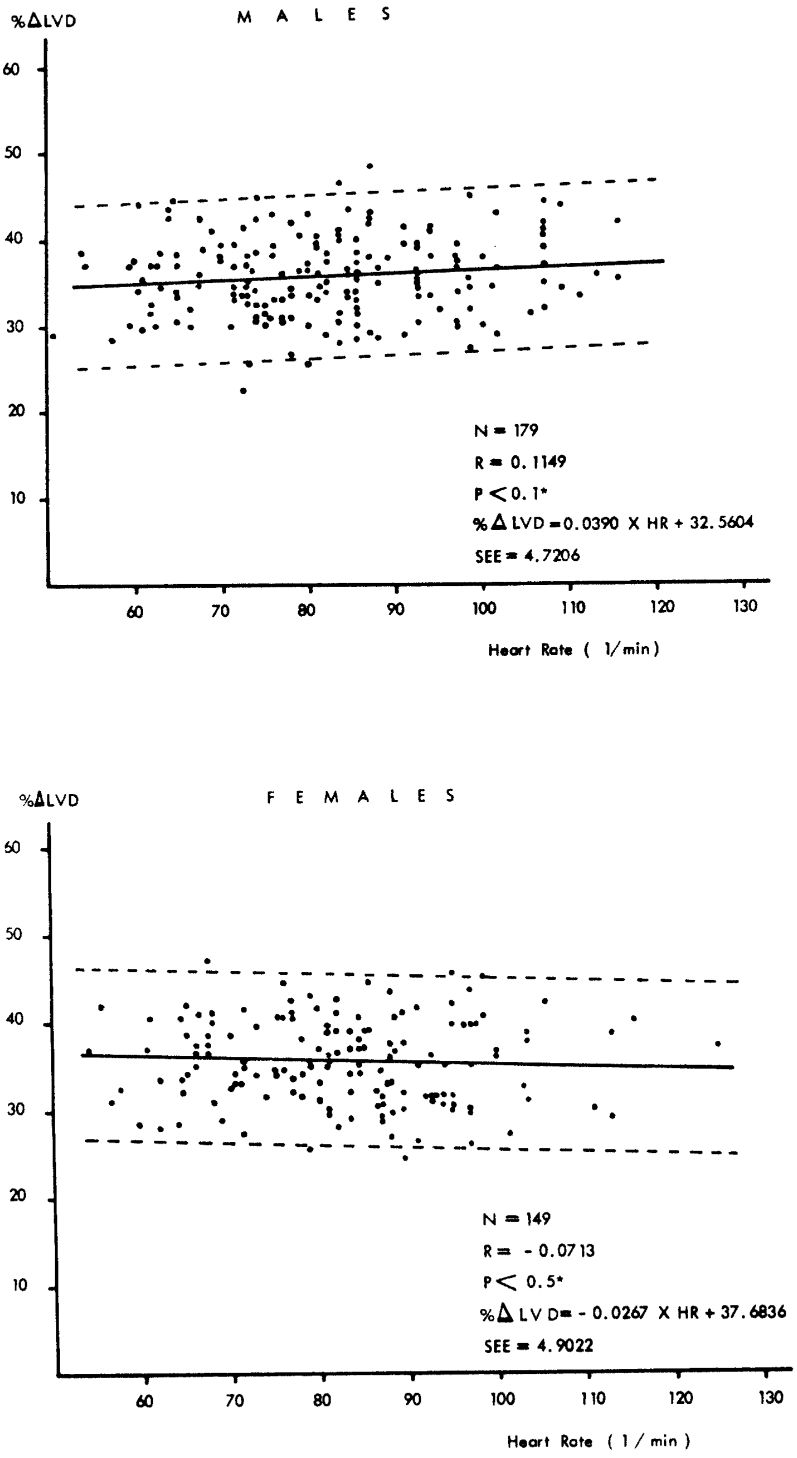
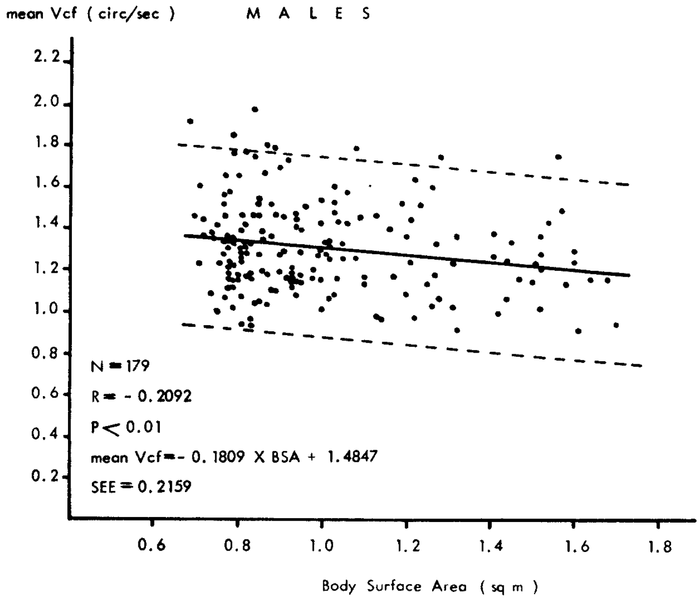


Fig. 3. Plottings of %⊿LVD against heart rate (HR) in males and females. There is a poor correlation between %⊿LVD and HR, and correlation coefficient positive in males and negative in females. Solid line, regression line ; broken lines, twice the standard error above and below the regression line. *Not significant.



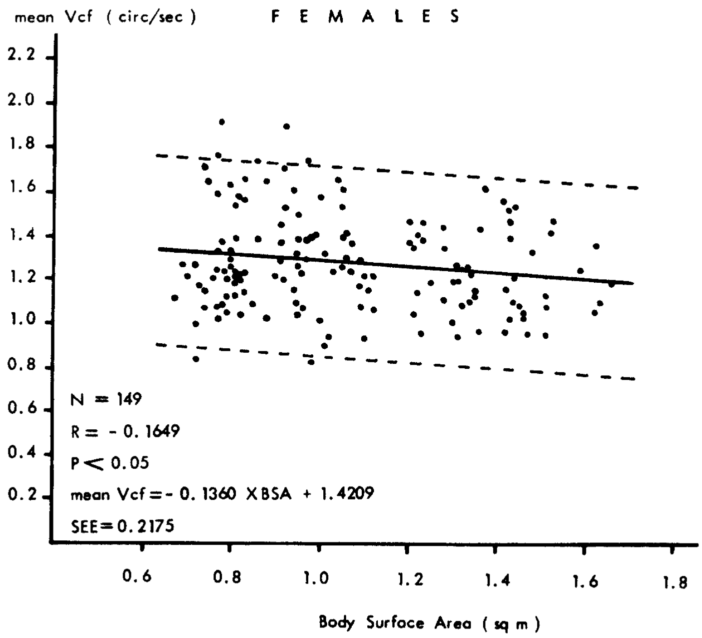
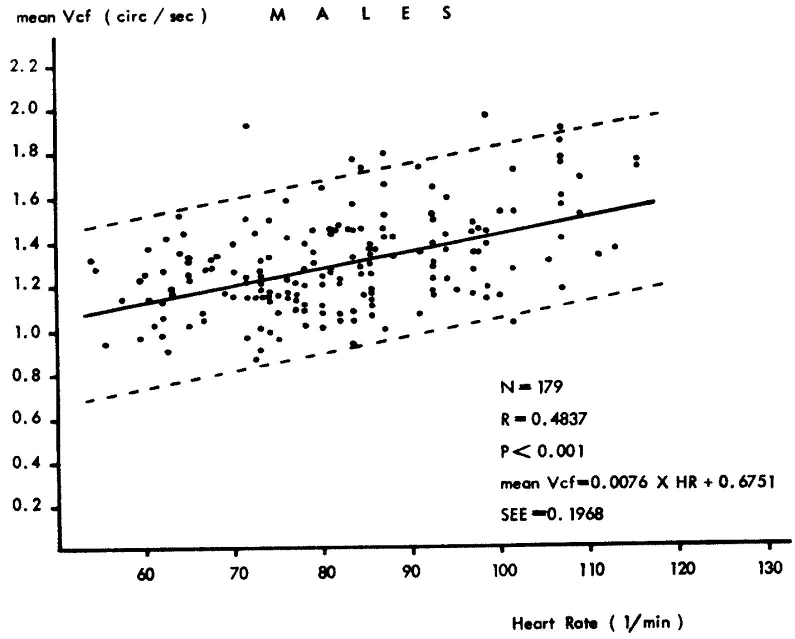


Fig. 4. Plottings of mean Vcf against body surface area (BSA) in males and females. Significant inverse relationship between mean Vcf and body surface area in both sexes. Solid line, regression line ; broken lines, twice the standard error above and below the regression line.



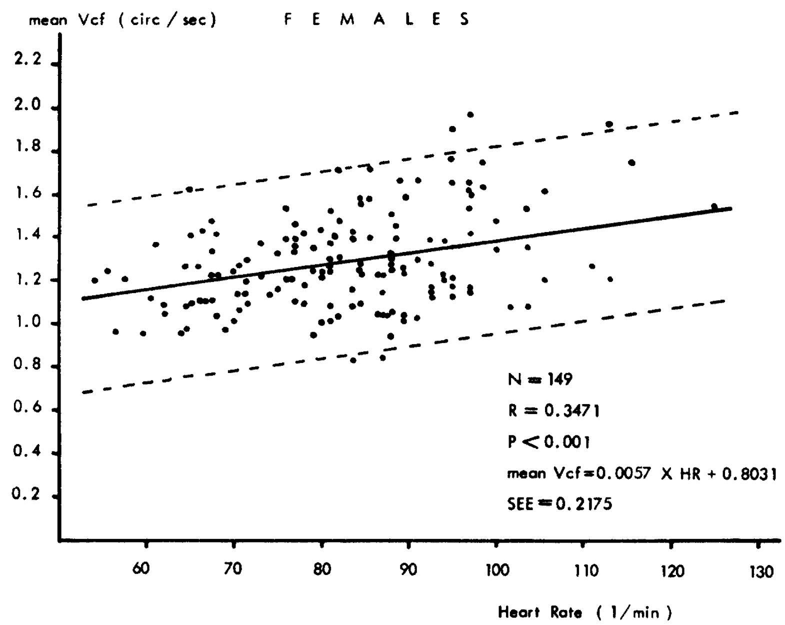


Fig. 5. Plottings of mean Vcf against heart rate (HR) in males and females. Strongly significant direct relationship between mean Vcf and heart rate. Solid line, regression line ; broken lines, twice the standard error above and below the regression line.

shortens with increase in heart rate (7). In the children we examined, heart rate at rest tended to decrease with age. Since mean Vcf is a fractional function inversely proportional to LVET, these relationships of mean Vcf with body surface area and heart rate would properly be attributable to the decrease in LVET with increase in heart rate.

DISCUSSION

Mean Vcf has proved its usefulness as an index of cardiac performance. At first, Vcf was determined only from angiocardiographic measurements (8, 9), and then later also from echocardiography (2, 10, 11). Angiocardiographic and echocardiographic mean Vcf's were well correlated, and, when properly determined, can yield similar values (12, 13). This method is most effective for detecting depressed cardiac performance in patients with various heart diseases except for those with asynergy of left ventricular myocardium (14, 15), and equally useful in adults (2, 8, 10, 12, 14, 16, 17), children (8, 18, 19, 20), infants (18, 19) and neonates (19, 21).

To calculate echocardiographic mean Vcf, the formula that is presented above is now well defined and universally used (3, 22). For the measurement of LVIDd, LVIDs, and LVET, however, various methods have been proposed. For instance, LVIDd is measured as maximum LVID (10), at the onset of upstroke of carotid pulse recording (11) or at the QRS complex (2, 5, 6, 12, 13, 14, 15, 16, 17, 18, 20) of electrocardiogram simultaneously recorded. LVIDs is measured at the closest approximation of interventricular septum and left ventricular posterior wall (5, 6, 10, 12, 13, 14, 17, 18), at the peak anterior movement of posterior wall (2, 15, 16, 20) or at the second heart sound of simultaneous phonocardiogram (11). The onset of LVET is timed at aortic valve opening (6), at the mitral valve closure (21, 22), at the onset of anterior movement of the posterior wall (2, 15, 18, 20), at the onset of upstroke of simultaneous carotid pulse recording (5, 12, 13, 15, 17) or at the QRS complex of electrocardiogram recorded simultaneously (5, 12, 14, 16, 20, 21). The end of LVET is also defined by various landmarks such as aortic valve closure (6), mitral valve opening (21, 22), maximal anterior movement of the posterior wall (2, 5, 12, 14, 16, 20) or incisural notch of carotid pulse recording (5, 12, 13, 15, 17).

Though some authors consider the differences in mean Vcf's determined by such various methods relatively small (5, 15), and the "normal" ranges of mean Vcf's in most reports quoted above are grossly from 1.00 to 1.60 (circ/sec), which is consistent with our own data, it would be difficult to define the normal range of echocardiographically determined mean Vcf.

We selected a method for measurement which we considered to be the most reasonable, but two points should be mentioned with respect to our methods. Paper speed of echocardiographic recording was only 50 mm/sec. since there may be a potential error in measured LVET when paper speed is less than 75 mm/sec (7, 23, 24, 25), such may have resulted in an inaccurate LVET. Carotid pulse recording was not feasible and we were forced to measure LVET from the echocardiographic recording itself.

Such is not the case with %⊿LVD, which does not contain a time factor and is independant of LVET. This index has been overlooked since its introduction (11), but has recently been given attention (6). %⊿LVD and mean Vcf are considered to be equally useful as indices of cardiac performance (19, 20). The %⊿LVD may even be superior to mean Vcf as it is not influenced by heart rate and is relatively restricted to a narrow range of distribution.

Echocardiographic %⊿LVD and mean Vcf have been shown to reflect well the state of cardiac contraction, to be less involved with error as a result of inadequate direction of the ultrasound beam and to be insensitive to change in cardiac geometry (26, 27).

In the present work, we have shown that %⊿LVD and mean Vcf in Japanese school age children are not so different from those of non-Japanese children and adults, not only in the value itself, but also in relation to body scale and heart rate. Sexual differences in those indices were also nil.

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