ORIGINAL ARTICLE

# Left ventricular chamber size predicts the race time of Japanese participants in a 100 km ultramarathon

**J Nagashima, H Musha, H Takada, M Murayama**

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See end of article for authors' affiliations

Correspondence to: Dr Nagashima, Yokohama Sports Medical Center, Internal Medicine Section, Yokohama-city, Japan; junagashima-circ@umin.ac.jp

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**Objective:** As a subanalysis of an echocardiographic study performed on 291 Japanese participants in a 100 km ultramarathon, to estimate predictors of race time.
**Methods:** A total of 247 male participants in a 100 km ultramarathon (age 20–73 years) were examined by echocardiography. Correlations between age, body surface area, monthly running distance, or echocardiographic variables and the race time were examined.
**Results:** According to simple regression analysis, age ($r$ = 0.299, p<0.0001), monthly running distance ($r$ = −0.388, p<0.0001), left ventricular end diastolic diameter ($r$ = −0.300, p<0.0001), and left ventricular end systolic diameter ($r$ = −0.325, p<0.0001) correlated significantly with the race time. When multiple regression analysis was performed, age (f = 2.364), monthly running distance (f = −0.113), and left ventricular end systolic diameter (f = −2.361) remained significant predictors of the race time.
**Conclusion:** Left ventricular diameter predicts the race time for a 100 km ultramarathon, in addition to age and amount of training.

As a subanalysis of our recent echocardiographic study on 291 Japanese participants in a 100 km ultramarathon,[1] we investigated predictors of the race time.

## SUBJECTS AND METHODS

### Subjects

The subjects were 247 men who were members of the Japan Association of Athletic Federations and participated in a 100 km ultramarathon. They were aged 20–73 years (mean (SD) 42.1 (9.4) years), and they all entered and completed a 100 km ultramarathon at Lake Saroma between 1995 and 1997. Written informed consent to participation in this study was obtained from all of the subjects. Approval of the study was also obtained from the research ethics committee of St Marianna University School of Medicine.

### Clinical variables

We sent questionnaires to each participant about their monthly running distance to assess the amount of training. Body surface area was calculated after measuring the weight and height of each subject. Heart rate was determined by limb lead electrocardiography combined with echocardiography.

### Recording and analysis of echocardiograms

Echocardiography was performed on the day before the 100 km ultramarathon. To record the echocardiograms, an EUB-565 and HDI-3000 (both from Hitachi Co, Tokyo, Japan) were used. Conventional M mode echocardiograms of the left ventricle, aorta, and left atrium were recorded at a paper speed of 50 mm/s via the parasternal approach after long axis cross sectional echocardiograms had been obtained. Digital measurement of the heart rate was performed five times, and the mean value calculated. Using the recorded data, left ventricular end diastolic diameter, left ventricular end systolic diameter, aortic diameter, and left atrial diameter were determined.

### Statistical analysis

Results are presented as mean (SD). Simple and multiple regression analyses were performed using age, monthly running distance, body surface area, heart rate, left ventricular end diastolic diameter, left ventricular end systolic diameter, aortic diameter, and left atrial diameter as dependent variables versus the race time as the independent variable. A probability value of less than 0.0001 was considered significant. The computer used for the statistical analysis was an Apple Macintosh (Apple Computer Inc, Tokyo, Japan), and the software program was Stat View 5.0J (SAS Institute Inc, Cary, North Carolina, UK).

## RESULTS

### Clinical variables

The mean race time was 624.0 (96.0) minutes (range 386–780), the mean monthly running distance was 408.7 (206.1) km (0–920), the mean body surface area was 1.66 (0.1) $m^2$ (1.36–2.05), and the mean heart rate was 50.4 (5.3) beats/min (38–79).

### Echocardiographic findings

The mean values of the echocardiographic variables were as follows: 61.7 (6.7) mm (range 42–75) for left ventricular end diastolic diameter, 39.5 (6.0) mm (23–55) for left ventricular end systolic diameter, 38.6 (3.9) mm (25–50) for aortic diameter, and 40.2 (4.8) mm (26–49) for left atrial diameter.

Simple regression analysis showed that age ($r$ = 0.299, p<0.0001), monthly running distance ($r$ = −0.388, p<0.0001), left ventricular end diastolic diameter ($r$ = −0.300, p<0.0001), and left ventricular end systolic diameter ($r$ = −0.325, p<0.0001) correlated significantly with the race time (figs 1 and 2). According to multiple regression analysis, age (f = 2.364), monthly running distance (f = −0.113), and left ventricular end systolic diameter (f = −2.361) remained significant predictors of the race time.

## DISCUSSION

The concept of athlete's heart was first advocated by Henschen in 1899 using percussion.[2] He described

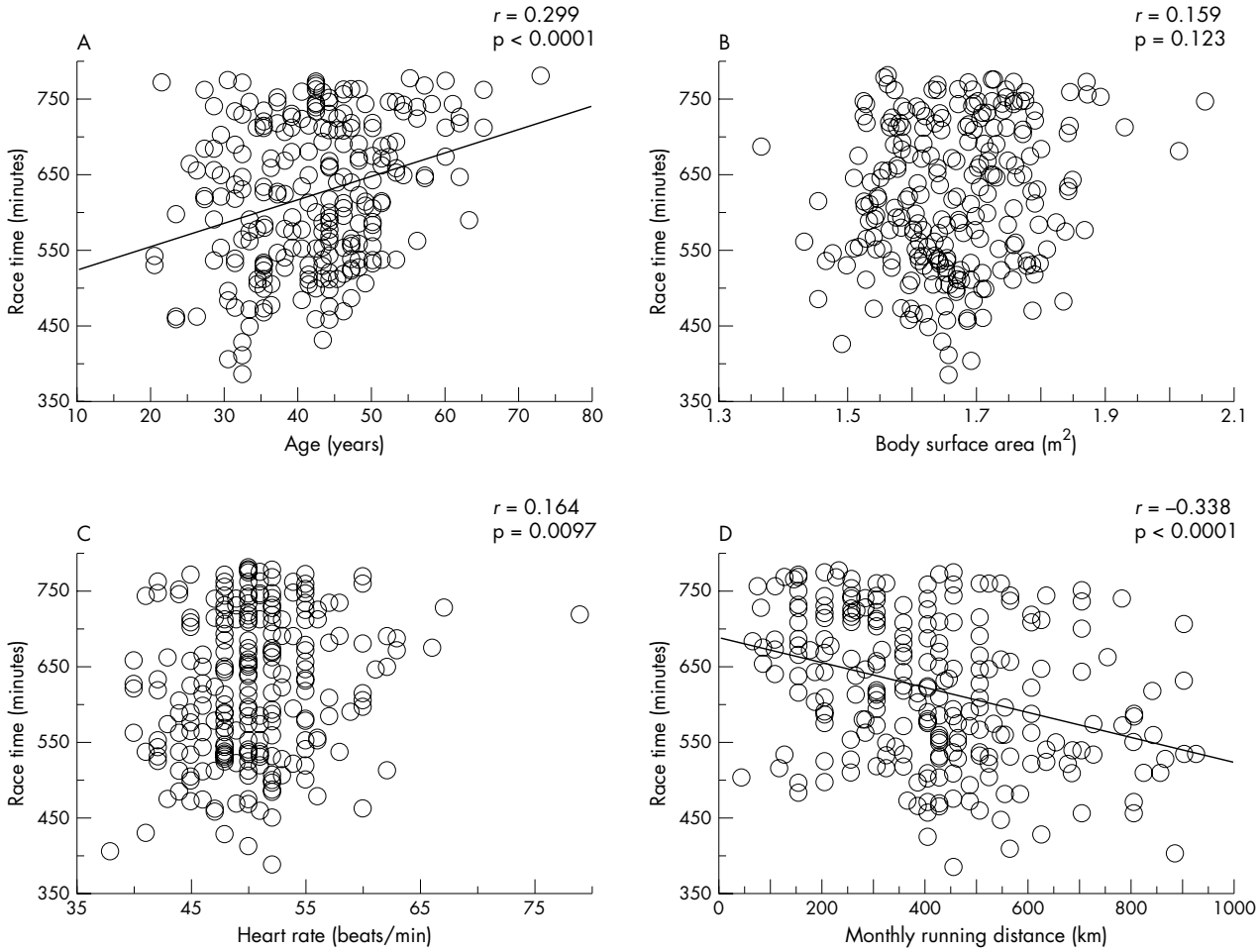


**Figure 1** Correlation between race time and (A) age, (B) body surface area, (C) heart rate, and (D) monthly running distance.

enlargement of the heart in cross country skiers and reported that athletes with larger hearts won their competitions. After his study, however, there were no further reports about the positive relation between heart size and sporting performance. On the other hand, there was a report denying the correlation between heart size and race time.[3]

In this study, we found that younger age, longer running distance a month, and larger left ventricle were predictors of a faster race time in the 100 km ultramarathon.

In previous studies, a higher maximum oxygen uptake ($V_{O_2MAX}$),[4] higher lactate threshold,[4] younger age,[5] and better biometeorological factors[6] have been shown to be predictors of better performance at long distance running. $V_{O_2MAX}$ has been reported to show a positive correlation between left ventricular mass and left ventricular dimensions in endurance athletes.[7 8] Furthermore, $V_{O_2MAX}$ has been reported to have a positive correlation with the total quantity of aerobic training.[9–11] We previously reported that left ventricular diameter correlates with the amount of training.[1] Accordingly, our finding that a larger left ventricular diameter predicts a faster race time may be related to a higher $V_{O_2MAX}$ due to a large amount of aerobic training.

### What is already known on this topic

- The left ventricular diameter correlates with the amount of training in 100 km ultramarathon runners

### What this study adds

- A larger left ventricle predicts a faster race time in the 100 km ultramarathon

### Study limitations

An important limitation of this study is that we did not evaluate other physiological factors with regard to running performance and we only performed one examination per participant. In the future, additional investigations, including determination of $V_{O_2MAX}$ and other variables, should be performed multiple times per participant to assess the reproducibility of these findings.

## CONCLUSION

Left ventricular diameter may predict the race time for a 100 km ultramarathon in addition to age and amount of aerobic training.

**Authors' affiliations**
**J Nagashima, H Takada, M Murayama,** Yokohama Sports Medical Center, Yokohama-city, Japan
**H Musha,** St Marianna University, Yokohama-city Seibu Hospital, Yokohama-city

Competing interests: none declared

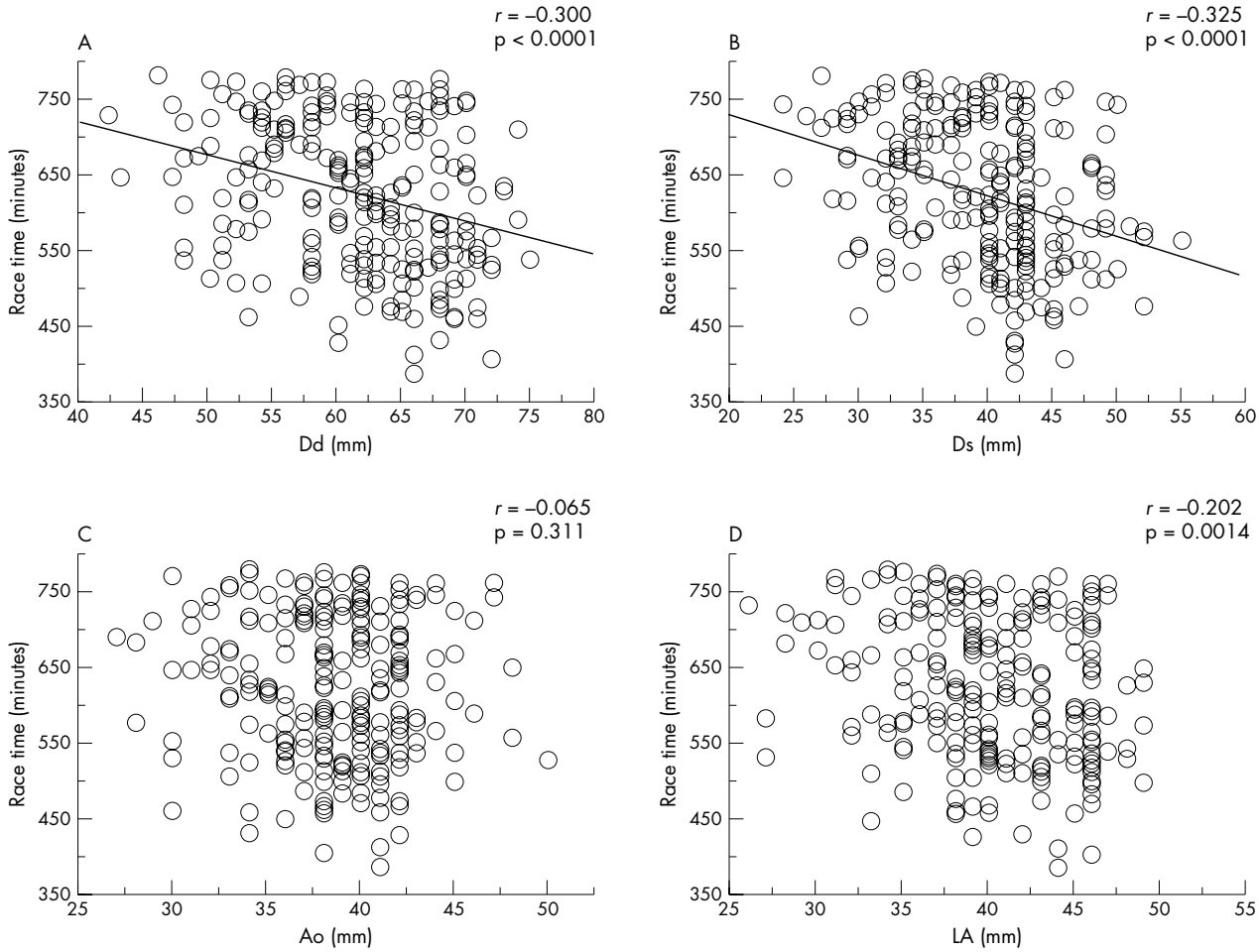


**Figure 2** Correlation between race time and (A) left ventricular end diastolic diameter (Dd), (B) left ventricular end systolic diameter (Ds), (C) aortic diameter (Ao), and (D) left atrial diameter (LA).

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## COMMENTARY

This paper reveals a negative correlation between the resting left ventricular diameter and the time needed to run a 100 km ultramarathon for men of a wide age and performance range. Resting left ventricular volume explained a considerable part of the dispersion of the 100 km race times, suggesting that a highly dilated chamber in a given population is in essence physiological. The extremely capacious left ventricle may reflect an unusual haemodynamic adaptation to copious running training in interaction with genetic and climatic factors, and thus should be viewed by clinicians as an adaptive and perhaps even desirable response to measures undertaken during the preparation for an ultra-long distance race.

**T Venckunas**
Sporto 6, Department of Applied Physiology and Health Education, Kaunas, Lithuania; t.venckunas@lkka.lt