Two new variables measured at rest to predict running performance

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By Alejandro Legaz-Arrese

ABSTRACT

Sport scientists and coaches both seek variables that measure the fitness of athletes. Numerous physiological variables have been shown to predict performance, particularly in endurance running. However, the majority of studies are on heterogeneous groups and few longitudinal studies exist. The author's fact-finding group has recently published several investigations on homogeneous groups of elite runners evaluated over several seasons. Their focus was on measurement of the left ventricular internal diameter at end-diastole (LVIDd) and lower limb skinfolds. Findings related to LVIDd include that the values in sprint and endurance runners increase with training and that the highest values are observed during the season of the athlete's best performance. It was also found that the assessment of lower limb skinfolds may be useful for predicting performance. Both sets of parameters can be simply measured at rest and it is recommended that coaches include these in the battery of tests for elite runners.

AUTHOR

Alejandro Legaz-Arrese is a Professor of Theory and Practice of Sports Training in the Department of Physical Education and Sports at the University of Zaragoza, Spain. He holds a Ph.D. in Physical Activity and Sports Science and a Masters degree in High Performance Sports. He is the responsible researcher for the "Human Movement" fact-finding group, which has been set up to explore the links between physiological variables and running performance.

Introduction

The ability to perform at a high level in sports has often been attributed to the physiological characteristics of the athlete. In endurance running, characteristics such as the maximal oxygen uptake (VO_2max), the velocity at VO_2max, the oxygen cost of running, the maximal fraction of VO_2max that can be sustained throughout the race, the kinetics of blood lactate accumulation during submaximal exercise and the characteristics of the muscular fibres have been found to have an important influence on performance.

However, the majority of the research relating physiological parameters to endurance running performance has dealt primarily with heterogeneous performance groups (coefficient of variation in performance > 6%). Moreover, longitudinal studies to establish the association between changes in physiological variables and

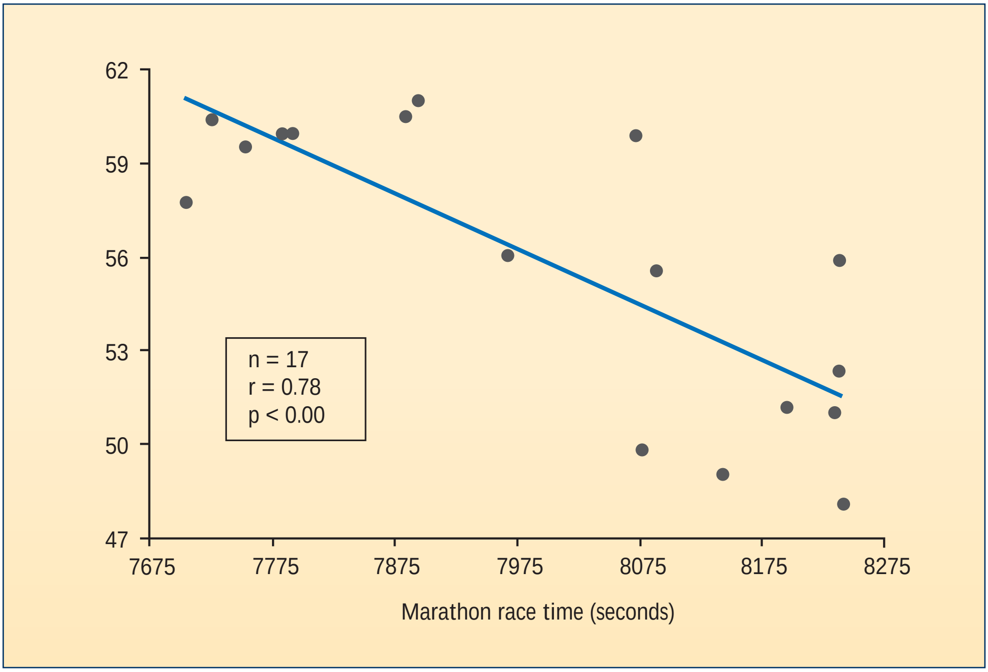

Figure 1: Plot of the association between left ventricular internal diameter at end-diastole (LVIDd) and marathon running performance in male athletes

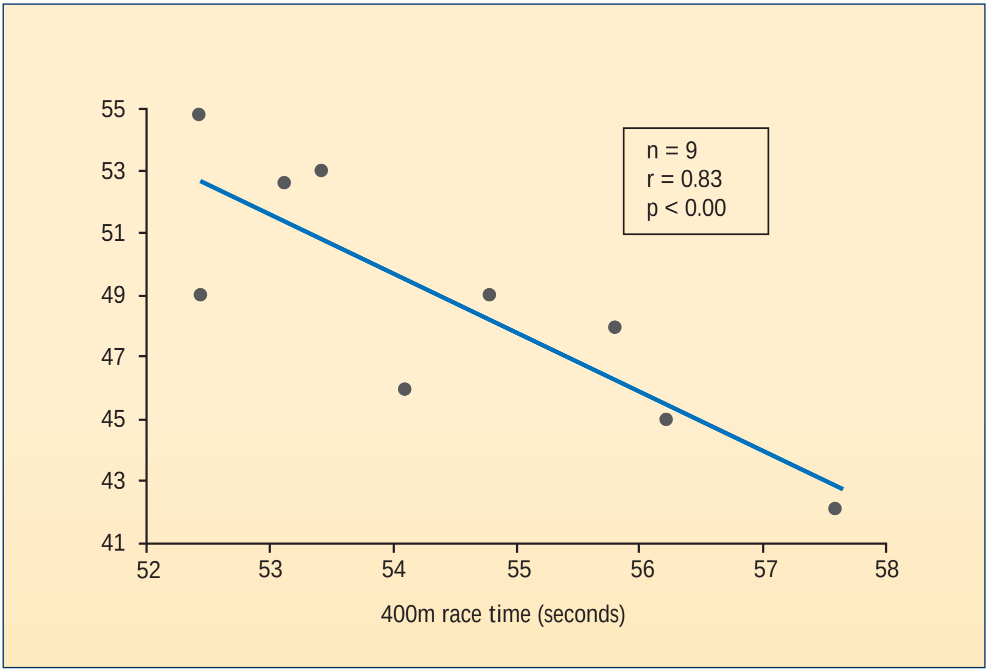

Figure 2: Plot of the association between left ventricular internal diameter at end-diastole (LVIDd) and 400m running performance in female athletes

changes in performance after training programmes are in short supply.

It is interesting to note that other parameters measured at rest, such as left ventricular internal diameter at end-diastole (LVIDd) and skinfold thickness, are not commonly used to observe changes in running performance. Echocardiography has been used to make comparisons between athletes engaged in different types of training as well as to define the upper limit to which the thickness of the left ventricular wall can be increased by training. However, no literature is available regarding the relationship of the morphology of the heart to performance. On the other hand, it has been postulated that in heterogeneous groups of runners additional adiposity contributes in a negative way to performance. Again, no previous studies have reported correlations between individual skinfold measurements and running performance.

Our fact-finding group has studied these parameters for their value in determining the fitness of elite runners. The aim of this work is to present coaches with the principal results and conclusions that we have published.

Contributions of our fact-finding group

Left ventricular internal diameter at end-diastole

In a cross-sectional study[1] with homogeneous groups of elite runners, we observed that in males LVIDd was associated with 100m performance (r = -0.68, P < 0.01), 10,000m performance (r = -0.70, P < 0.001), and marathon performance (r = -0.78, P < 0.001, Figure 1); and in females, LVIDd was correlated significantly with 400m performance (r = -0.84, P < 0.001, Figure 2).

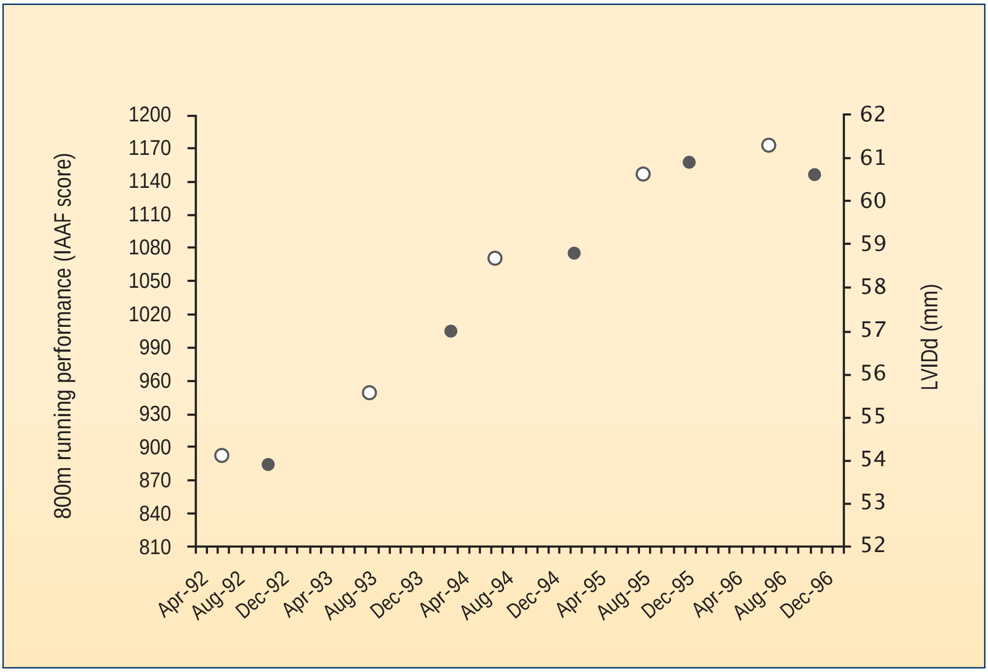

Figure 3: Plot of the changes in left ventricular internal diameter at end-diastole (LVIDd) against changes in 800m running performance caused by intense athletic conditioning in a male runner (open circles = Running performance, IAAF score; solid circles = LVIDd, mm)

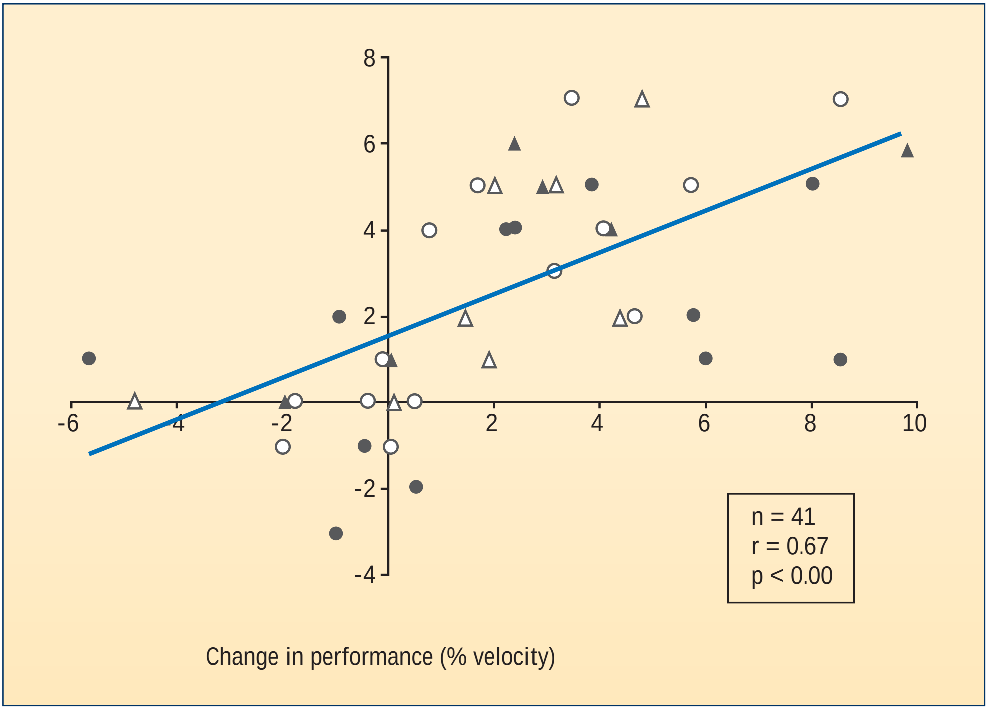

Figure 4: Plot of the changes in left ventricular internal diameter at end-diastole (LVIDd) against changes in running performance caused by intense athletic conditioning over a three-year period (open triangle = male sprint-trained runners; solid triangle = female sprint-trained runners; open circles = male endurance-trained runners; solid circles = female endurance-trained runners)

In a group of 10 male marathon runners[2], the results of a stepwise multiple regression analysis using marathon time as the dependent variable and numerous antropometric, echocardiographic, haematologic and ergometric variables as independent variables yielded an R2 = 0.983. In the equation for prediction of marathon time, LVDId was included:

Marathon time = 8408.623 + 240.632 (lactate at 10 km/h^{-1}) – 18.255 (LVDId) + 22.522 (lactate at 22 km/h^{-1})

In 15 of the 20 elite middle- and long-distance runners evaluated over several seasons[3] (at least four times), the higher value of the LVIDd was observed during the season in which the best performance was obtained. Furthermore, individual analysis showed that LVIDd was associated with running performance in seven of the 11 male runners and in three female runners.

In a group of 23 male and 18 female runners engaged in intense conditioning over a three-year period[4], training resulted in an increase in performance and LVIDd. There were no significant differences in these changes between sex and sprint- vs endurance trained athletes. Improvements in performance were consistently associated with an increase in LVIDd (Figure 4). These associations were true for males and females, sprint and endurance trained runners and classification. Thus, changes in performance were related with those in LVIDd for male runners ($r = 0.79$, $P < 0.001$) and female runners ($r = 0.52$, $P < 0.05$) and for sprint and endurance trained runners ($r = 0.73$, $P < 0.01$) ($r = 0.56$, $P < 0.01$).

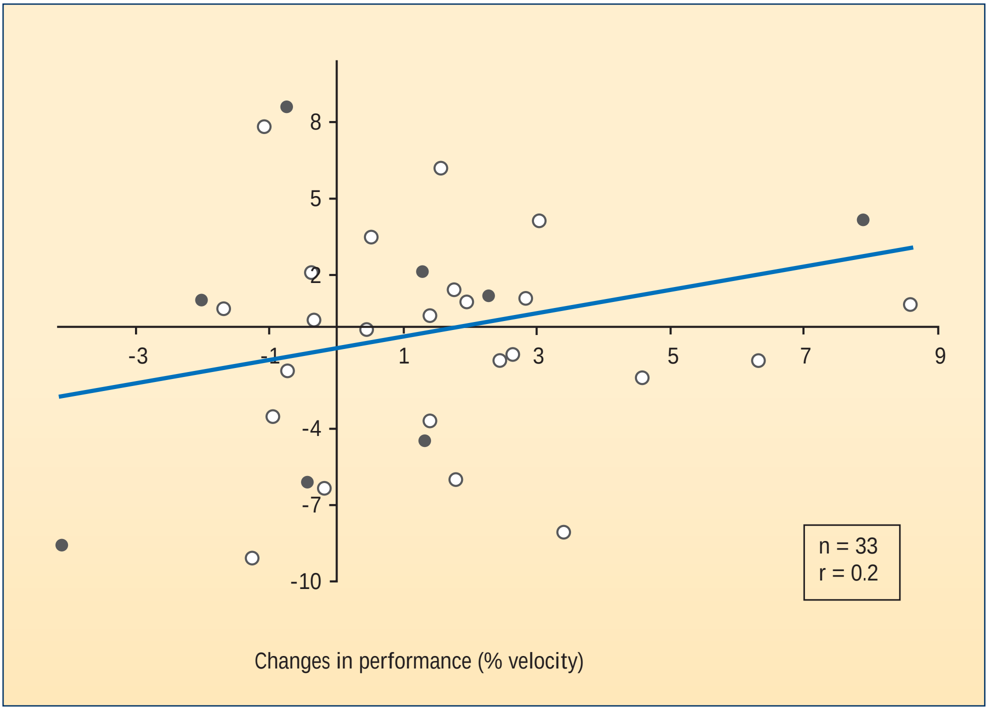

Figure 5: Plot of the changes in VO_2max (ml/kg^{-1}/min^{-1}) against changes in running performance (% velocity) caused by intense athletic training over a three-year period in endurance runners (open circles = male runners; solid circles = female runners)

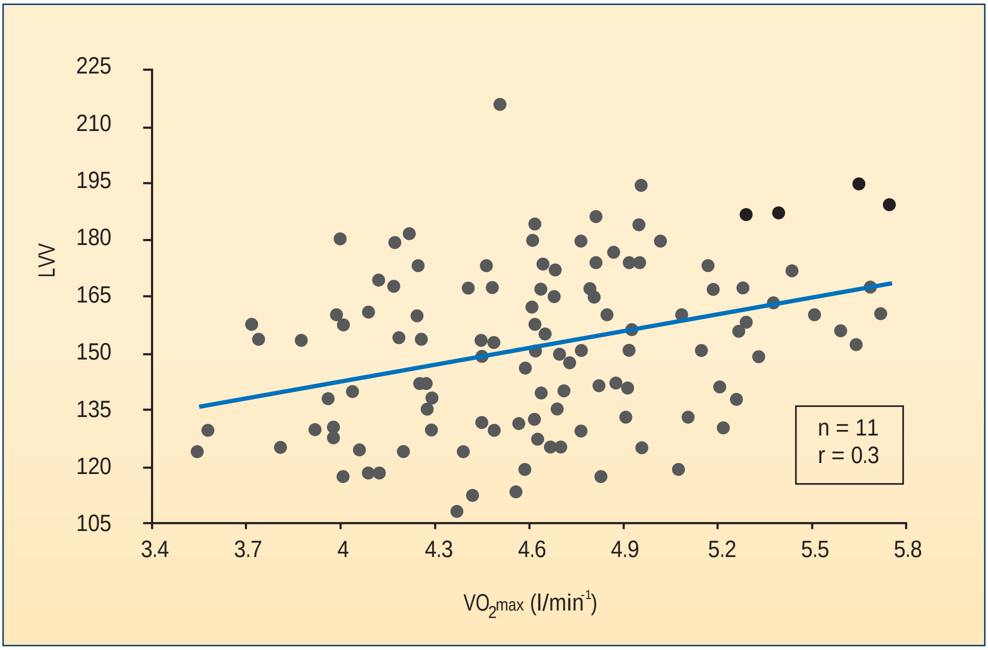

Figure 6: Plot of the association between left ventricular volume (LVV) and VO_2max in male athletes

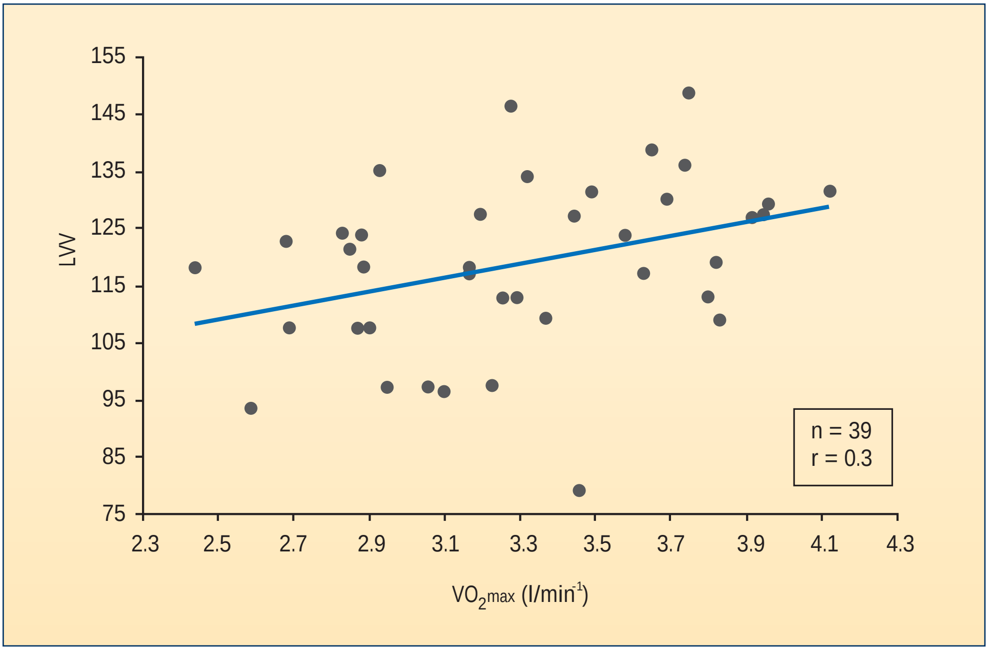

Figure 7: Plot of the association between left ventricular volume (LVV) and VO_2max in female athletes

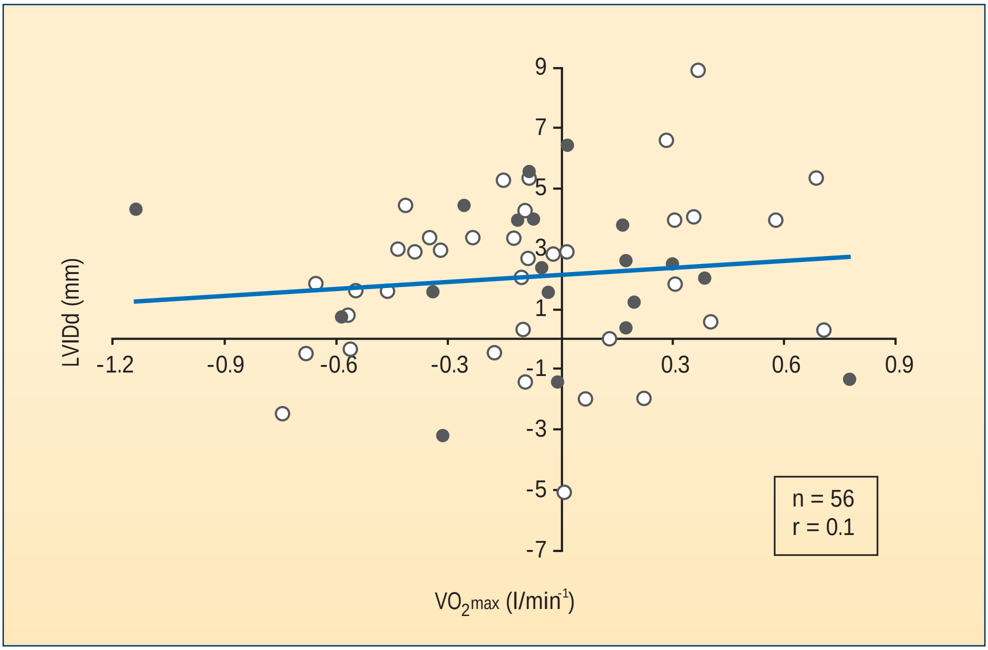

Figure 8: Plot of the changes in left ventricular internal diameter at end-diastole (LVIDd) against changes in VO_2max caused by intense athletic conditioning over a two-year period (open circles = male endurance-trained runners; solid circles = female endurance-trained runners)

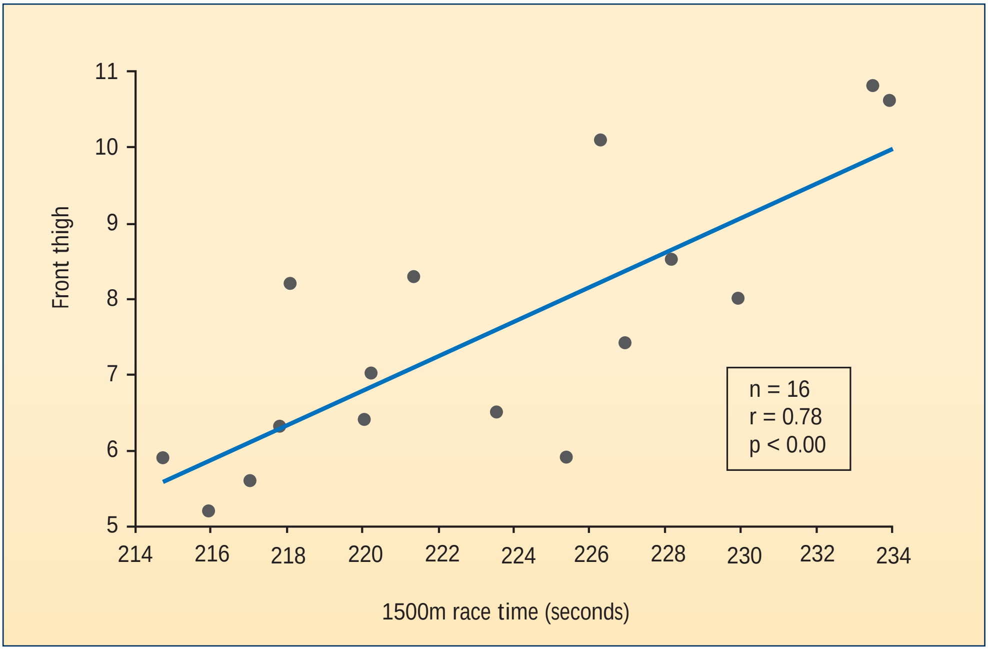

Figure 9: Plot of the association between front thigh skinfold measurement and 1,500m performance in male athletes

The importance of enlargement of LVIDd for running performance is not clear. Possibly, a higher LVIDd can increase the VO_2max. However, in a recent longitudinal study[5] we observed that in elite endurance-trained runners the VO_2max remained essentially unchanged and was not related with the changes in running performance (Figure 5).

In addition, an analysis of unpublished data evidences that left ventricular volume is not related with VO_2max in a large sample of male (Figure 6) and female (Figure 7) elite runners and that the changes in LVIDd over a two-year period of training were not related with the changes in VO_2max (Figure 8). These new data turn on another way in the discussion of central or peripheric limitation of the VO_2max.

It is possible that the increment of the LVIDd is associated to another physiological processes permitting the easier recovery of the organism, a more rapid start of oxygen transport mechanisms, a greater capacity of the athlete to pump large volumes of blood and oxygen to the muscles with a lower heart rate, a reduction in the rate of expiratory ratio, a lower utilisation of carbohydrates, and to processes such as the removal of products derived from metabolism, functional economy and other environmental factors and the body fluid losses in order to prevent hyperthermia.

The lower limb skinfolds

In a cross-sectional study[6] we observed that in males the sum of six skinfold measurements and the values for the biceps, triceps, subscapular, pectoral, iliac crest and abdominal skinfols - were not associated with performance at any of the distances. However, high correlations were found between the front thigh ($r = 0.78$ $P < 0.001$, Figure 9; $r = 0.59$ $P < 0.05$) and medial calf skinfold measurements ($r = 0.58$ $P < 0.05$, $r = 0.57$ $P < 0.05$) and 1,500m and 10,000m performances. Significant associations were also found between the extremity/trunk fat ratio and 100m and 1,500m performances ($r = 0.52$, $P < 0.05$,

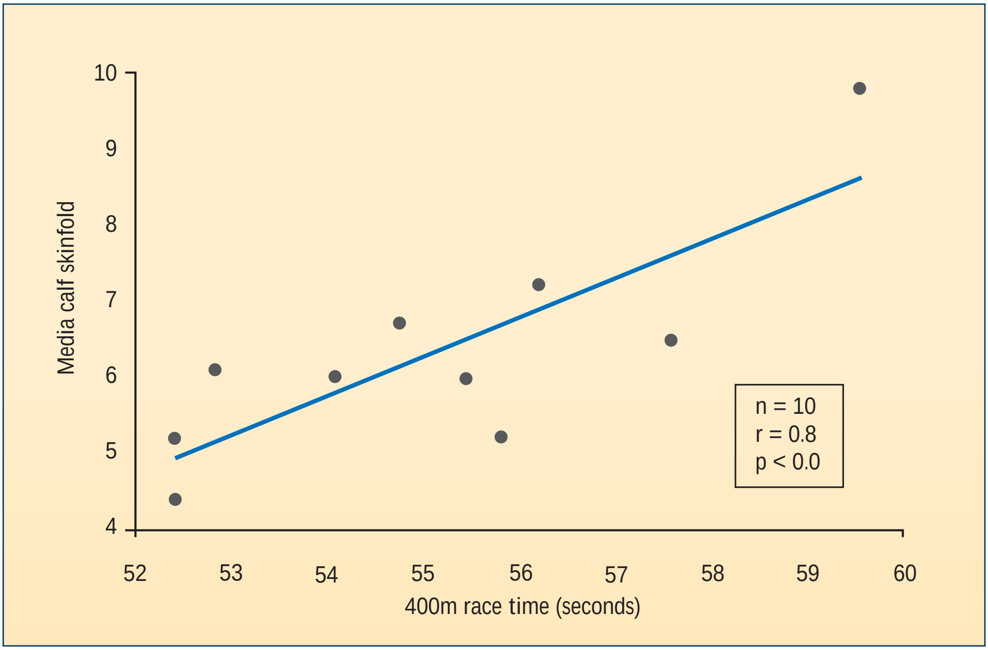

Figure 10: Plot of the association between medial calf skinfold measurement and 400m performance in female athletes

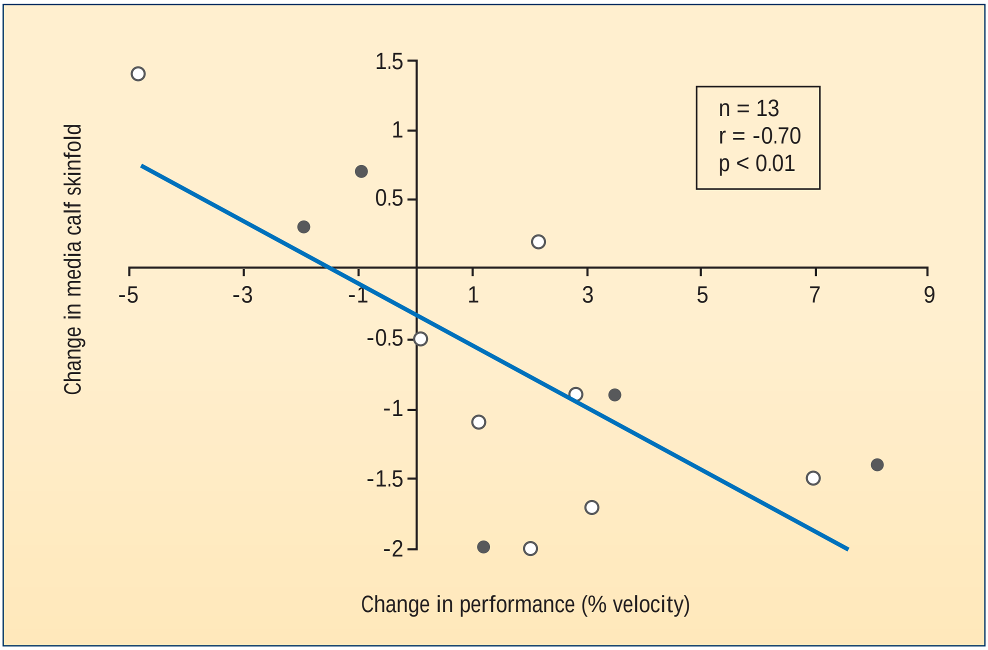

Figure 11: Plot of the changes in medial calf skinfold measurement against changes in running performance caused by intense athletic conditioning over a three-year period (open circles = male sprint-trained runners; solid circles = female sprint-trained runners)

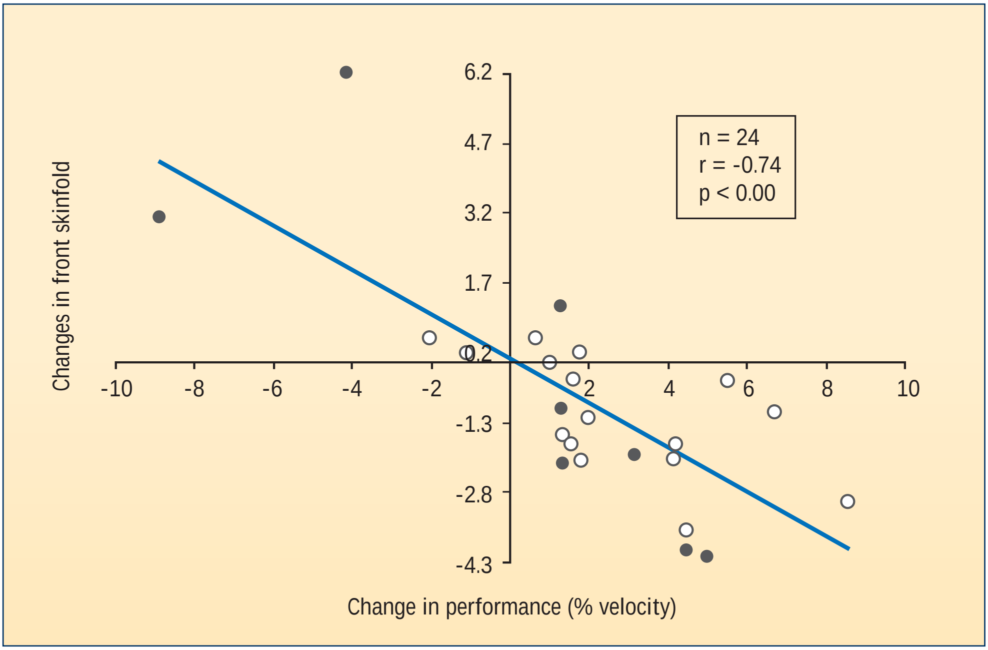

Figure 12: Plot of the changes in front thigh skinfold against changes in running performance caused by intense athletic conditioning over a three-year period (open circles = male endurance-trained runners; solid circles = female endurance-trained runners)

r = 0.60 P < 0.05). In the female athlete study, only the 400m, 1,500m and marathon groups had optimal numbers of subjects. There were positive relationships between 400m performance and the skinfold measurements of the front thigh (r = 0.71, P < 0.05) and medial calf (r = 0.81, P < 0.001, Figure 10). Moreover, the extremity/trunk fat ratio was associated with 400m (r = 0.69, P < 0.05) and 1,500m performances (r = 0.77, P < 0.05).

In a longitudinal study of 24 male and 13 female runners over a three-year period[7], training resulted in a significant increase in performance and decreases in the sum of six skinfold measurements; the abdominal, front thigh, medial calf measurements; and the ratio of extremity to trunk skinfold measurements. With the exception of the abdominal skinfold, there was no significant difference linked to the trunk skinfolds. Improvements in performance were consistently associated with a decrease in the measurements of the lower limb skinfolds. These associations were true for males and females and for both sprint and endurance trained runners. Thus, the changes in performance were related with the changes in front thigh (r = -0.71, P < 0.001) and medial calf (r = -0.67, P < 0.001) skinfolds, and the sum of six skinfolds measurements (r = -0.64, P < 0.001) and E/T (r = -0.55, P < 0.01) in males. In female runners, a similar association was presented for the front thigh (r = -0.62, P < 0.05) and medial calf (r = -0.78, P < 0.01) skinfolds and for the sum of six skinfold measurements (r = -0.79, P < 0.001). In sprint trained runners, the changes in performance were associated with the changes in front thigh (r = -0.61, P < 0.05), medial calf measurements (r = -0.70, P < 0.01, Figure 11) and the sum of six skinfold measurements (r = -0.81, P < 0.001). In endurance trained runners, the relationship was also observed for the front thigh (r = -0.74, P < 0.001, Figure 12), medial calf (r = -0.66, P < 0.001), and the sum of six skinfod measurements (r = -0.66, P < 0.001) and E/T (r = -0.60, P < 0.05).

In view of these results, it is probable that the lower extremity skinfolds facilitate an individual´s running performance due to the fact that a higher relative body mass quantity distributed in the lower limbs would most likely require a greater muscular effort to accelerate the legs, and, in theory, the energetic expenditure at the same velocity would be higher.

Conclusions

Coaches and distance runners turn to the physiology laboratory for information that helps measure fitness status and guide the training. The maximal aerobic power test on a treadmill is used in middle- and long-distance trained runners. However, a correct evaluation is only possible through this method if the athlete is very motivated and completely recovered from previous training. This requires an interruption of the training programme and therefore coaches do not habitually utilise this type of evaluation. Moreover, scientific studies have not demonstrated an obvious utility of the maximal aerobic power test for the control of training.

The control of training in sprint trained runners by means of the measurement of physiological variables is even more difficult.

This article presents analysis of data on cardiac dimensions and skinfold thicknesses from a very impressive sample of runners. Different results evidence that the assessment of skinfold values in the lower limbs and the LVIDd may be useful in the prediction of performance. These physiological parameters, which are very easy to measure when an athlete is at rest, were related to running performance. Therefore, it is recommended that LVIDd and skinfold thicknesses be included in the battery of tests for elite runners.

Please send all correspondence to:
Prof Alejandro Legaz-Arrese
alegaz@posta.unizar.es

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