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ANTHROPOMETRIC AND TRAINING VARIABLES RELATED TO 10km RUNNING PERFORMANCE

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ABSTRACT

Sixty male distance athletes were divided into three equal groups according to their personal best time for the 10km run. The runners were measured anthropometrically and each runner completed a detailed questionnaire on his athletic status, training programme and performance. The runners in this study had similar anthropometric and training profiles to other distance runners of a similar standard. The most able runners were shorter and lighter than those in the other two groups and significantly smaller skinfold values ($P < 0.05$). There were no significant differences between the groups for either bone widths or circumferences but the elite and good runners had significantly higher ponderal indices ($P < 0.05$) than the average runners, indicating that they are more linear. Elite and good runners were also less endomorphic but more ectomorphic than the average runners. The elite runners trained more often, ran more miles per week and had been running longer ($P < 0.05$) than good or average runners. A multiple regression and discriminant function analysis indicated that linearity, total skinfold, the type and frequency of training and the number of years running were the best predictors of running performance and success at the 10km distance.

Key words: Physique, Body composition, Somatotype, Training, Male distance runners

INTRODUCTION

A large volume of research has considered the anthropometrics of athletic performance and in particular distance running. However, it is only in the last decade that the influence of training programmes on physique and performance levels has been examined. For example Pollock et al (1977), in their study of marathon runners, made comparison between athletes of various standards, finding that champion athletes had lower bodyweights and less fat than moderately trained and even well trained athletes of a similar age. Similarly Costill et al (1970) reported that highly trained marathon runners had 7.5% body fat, 5% less than college students and 9% less than sedentary men of their own age. Highly trained athletes also differ from the more general athletic population in that they are less endomorphic and more mesomorphic. In contrast, distance athletes who do mainly aerobic training involving many miles run each week tend to be even lower in endomorphy and mesomorphy but have greater ectomorphy than other athletes (Bale, 1983; Bale, 1986; Thorland et al, 1981).

The purpose of this investigation was to consider the physique and anthropometric variables of athletes of various running standards, in relation to their type and amount of training and to examine these variables as potential predictors of distance running performance.

SUBJECTS

Sixty athletes in training for the national 10km road race championships volunteered as subjects for this study. This distance was selected due to its appeal to a wide range of the running population. Both the longer distance marathon runners and track specialists consider the 10km to be the best distance for an equal meeting, prior to the start of the athletics season when they are just completing their winter training. These subjects were divided into three equal groups according to their best times for the 10km distance. Group I, the elite runners, included all those runners who have personal best times of under 29mins 30secs. This group included eight athletes who were members of the British National road running team. Group II, the good runners, contained runners who had achieved a time between 30 and 35mins for a 10km, a level of performance which makes these runners eligible for the national 10km championships. The third group all had personal bests of between 35 and 45 minutes, an average standard of performance

METHOD

The anthropometric data was collected over four measuring sessions during one week and all subjects completed a detailed questionnaire on their athletic status, training programme and performance. For comparison between the three groups the Durnin and Rahaman (1967) regression equation for predicting body density from skinfold measurements, and the Siri equation (1956) were used to give an indication of per cent fat, absolute fat and lean body mass. However, only skinfold values were entered into the correlation, multiple regression and discriminant function analysis to avoid the problems of predicting body composition from skinfold data (Norgan and Ferro-Luzzi, 1985; Sinning et al, 1985; Wilmore; 1983).

Height was recorded to the nearest cm using a portable stadiometer and weight was recorded using a Salter 209 balance. Biceps, triceps, subscapular, suprailiac and medial calf skinfolds were measured to the nearest mm using Holtain skinfold calipers. The humerus and femur bicondylar diameters were measured using a broad blade Harpenden anthropometer and the flexed biceps and calf circumferences were measured using a flexible steel tape. Body type was calculated from the Heath Carter somatotype form (Heath and Carter, 1967) and plotted on a somatochart using the x and y co-ordinates of the Somatotype dispersion index (Ross and Wilson, 1973).

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STATISTICAL TECHNIQUES

Analysis of variance was used to examine the difference between group means for the different variables. In order to evaluate the predictive value of the anthropometric and training variables in relation to performance (career best times for the 10km) a univariate multiple correlation analysis was made and variables with p values of less than 0.05 were entered into a stepwise multiple regression analysis. Finally a canonical discriminant function analysis was performed. The analysis calculates significant discriminant functions to determine whether the variables are able to differentiate between the groups of runners.

RESULTS AND DISCUSSION

The means and standard deviations for age, physique and body composition are presented in Table I together with any significant differences between the three groups of runners. The runners in this study, although they represent a broad spectrum of performance levels, have similar anthropometric profiles to other distance runners measured by Costill et al (1970), McGowan et al (1985), Pollock et al (1977), Reilly and Foreman (1983, 1984) and Thorland et al (1981) and the better runners have both anthropometric and training profiles very similar to those of elite runners in the above studies.

TABLE I

Means and Standard Deviations for age, physique and body composition of the three groups of runners

	Elite group n = 20	Good group n = 20	Ave. group n = 20
Variable			
Age (year)	28.1 ± 3.0	25.0 ± 4.6	26.3 ± 7.5
Height (cm)	175.1^{c} ± 3.8	179.9 ± 3.0	173.5^{c} ± 9.5
Weight (kg)	64.4^{b} ± 2.4	66.3^{b} ± 5.0	69.2 ± 3.7
Skinfolds (mm)			
Triceps	5.4 ± 0.4	8.4^{ab} ± 1.1	9.5^{a} ± 2.1
Biceps	3.6^{b} ± 0.5	3.7^{b} ± 0.7	4.4 ± 0.7
Subscapular	7.6 ± 0.5	8.5^{ab} ± 1.4	9.7^{a} ± 1.6
Suprailiac	3.6 ± 0.7	4.9^{a} ± 0.9	5.0^{a} ± 0.7
Med. Calf	4.5^{b} ± 0.5	4.6^{b} ± 1.4	5.8 ± 1.2
Total Skinfold	24.6 ± 1.0	29.4^{ab} ± 3.5	34.9^{a} ± 3.7
Bone Widths (cm)			
Humerus	6.7 ± 0.3	6.9 ± 0.4	6.9 ± 0.3
Femur	9.6 ± 0.3	9.3 ± 0.5	9.4 ± 0.4
Circumferences (cm)			
Biceps	29.4 ± 1.2	28.8 ± 1.6	29.1 ± 1.9
Calf	36.8 ± 2.5	36.2 ± 2.0	35.0 ± 3.0
Body Composition			
Density	1.081 ± 0.001	1.075^{ab} ± 0.003	1.071^{a} ± 0.005
Per cent Fat	8.0 ± 0.5	10.7^{ab} ± 1.3	12.1^{a} ± 1.5
Abs. Fat (kg)	5.2 ± 0.4	7.0^{ab} ± 1.2	8.3^{a} ± 1.1
Lean Body Mass (kg)	59.0 ± 2.4	59.4 ± 4.2	60.5 ± 3.0
Ponderal Index	13.2^{b} ± 0.3	13.5^{b} ± 0.4	12.9 ± 0.6

^{a} significantly different from elite runners, $P < 0.05$
^{b} significantly different from average runners, $P < 0.05$
^{c} significantly different from good runners, $P < 0.05$

As Table I shows, there is a decrease in skinfold values with an increase in 10km performance. The skinfold measurements of the elite runners are the smallest and they are all significantly smaller than those of the average runners. Apart from the biceps skinfold, the differences in skinfold values between the elite and good runners were also significant ($p < 0.05$). When compared with those for the average population all three groups of runners have smaller skinfolds when related to their body weights. These findings suggest that the runners have a greater percentage of their body weight as lean tissue rather than fat and the superior distance runners have relatively less fat than the less able performers. Studies of women distance runners (Bale et al, 1985; Upton et al, 1983) and male runners (Reilly and Foreman, 1983; 1984) have suggested that these lower fat levels may be related to their training. The elite runners train longer and more often than runners of more moderate ability.

As expected, given the significant differences in the skinfold values the computed densities of the elite runners are significantly higher and the absolute fat and per cent fats are significantly lower. These estimated values were similar to those of top class distance runners calculated from densities measured by both underwater weighing and regression analyses (McGowan et al, 1985; Reilly and Foreman, 1983, 1984) but they were larger than those of elite distance runners reported by Carter et al (1982), Costill et al (1970), Fleck (1983), Pollock et al (1977) and Thorland et al (1981).

The mean ponderal indices of the elite and good runners were significantly greater than those of the average runners, indicating that these first two groups are more linear than the latter group. Hirata (1979) considered a high ponderal index as one of the fundamental attributes of distance running because success is effected by the mass carried by the individual.

The individual somatotypes of the runners are plotted in Fig. 1. Unlike the female marathon runners in a similar study by Bale et al (1985) the somatotypes do fall into more defined and separate groups. Though the elite runners are similar in mesomorphy they are less endomorphic than the other two groups and the elite and good runners are in general more ectomorphic than the average runners. Whilst the elite and good runners were found exclusively in the ectomesomorphic and meso-ectomorphic sectors of the somatochart the average runners had a wider distribution and were found mainly in the endomesomorphic sector. The somatotype ratings of the good and elite runners are similar to those of other distance athletes and support the concept that top class runners tend to be less endomorphic and more ectomorphic (Bale, 1983; Housh et al, 1984; Thorland et al, 1981).

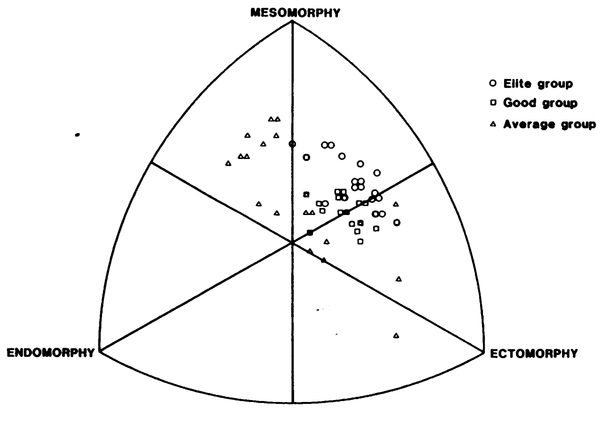

Fig. 1: Individual somatotypes of the male 10km runners.

The means and standard deviations of the training variables are presented in Table II. Unlike a similar study of women marathon runners (Bale et al, 1985), these athletes were not asked whether they had a coach, otherwise the questions asked were similar.

TABLE II

Results of the questionnaire on training

Variable	Elite group n = 20	Good group n = 20	Average group n = 20
	Mean	Mean	Mean
Number of Years Running	8.1 ± 2.2	5.2[ab] ± 2.2	3.3[a] ± 1.8
Number of Miles Run per Week	67.8 ± 6.2	57.5[ab] ± 7.5	38.1[a] ± 13.2
Number of Training Sessions per Week	10.7 ± 1.2	7.3[ab] ± 1.1	4.8[a] ± 1.4
Long Steady Runs (% of total dist.)	59.5 ± 10.0	76.5[ab] ± 8.3	87.0[a] ± 12.9
Fast Runs (% of total dist.)	16.5 ± 8.8	5.5[a] ± 5.1	8.0[a] ± 8.3
Interval Runs (% of total dist.)	21.5 ± 8.8	9.3[ab] ± 12.4	1.5[a] ± 4.9
Fartlek Runs (% of total dist.)	2.5[c] ± 5.5	8.7 ± 8.3	3.0[c] ± 5.0

[a] significantly different from elite runners, $P < 0.05$
[b] significantly different from average runners, $P < 0.05$
[c] significantly different from good runners, $P < 0.05$

Like the elite women marathon runners in this earlier study, the elite male 10km runners also trained more often, ran more miles per week and had been running longer. Similarly the training programmes of the men as expressed as percentages of the total mileage differed significantly according to their level of performance. The most commonly used form of training by all the runners was long slow runs; however, the extent of this type of training varied significantly between the elite runners and the other two groups. They did significantly less distance training but more fast runs and interval training. Product moment correlations between 10km race times and most of the training variables were high but fartlek training showed only low correlations. This questions its use as a useful training method and suggests that the 'old' type of fartlek training has now been replaced in the training schedules of many athletes by interval work. The training programmes of the elite runners in the present study suggest that pre-season training schedules include both interval and speed work as well as slower distance training. A high correlation between the frequency of training and 10km performance also suggests that this aspect is as important as the quality and length of training.

The multiple regression equations for predicting 10km race time and the coefficients of determination (r^2) are presented in Table III. They indicate that the addition of predictor variables of sessions of training, miles per week, the number of years running and ectomorphy significantly improve the prediction of performance over 10km. The percentage of total variance accounted for by these equations was 85.6%. These findings demonstrate the importance of anthropometric and training variables as predictors of distance running performance, although, as Reilly and Foreman (1984) comment, the ability of multiple regression analysis for predicting performance is dependent upon such factors as the specificity of the subjects used, race distance and environment. Housh et al (1984) and Reilly and Foreman (1984) also emphasise the importance of cardiovascular factors such as maximum oxygen uptake and anaerobic threshold.

TABLE III

Multiple correlations and regression analysis of the anthropometric and training variables

Variables	r	R	r^2	SEE	Regression Equation	
Sessions per per week	−0.87	0.87	0.75	2.28	Time = 44.27	−1.44 (sessions)
Miles run per week	−0.84	0.89	0.80	2.08	Time = 46.32	−0.91 (sessions) −0.11 (miles per wk)
Years running	−0.70	0.91	0.83	1.92	Time = 46.45	−0.68 (sessions) −0.11 (miles per wk) −0.38 (years)
Ectomorphy	−0.40	0.93	0.86	1.78	Time = 47.93	−0.68 (sessions) −0.10 (miles per wk) −0.38 (years running) −0.68 (ectomorphy)

The canonical discriminant function analysis produced two significant functions (Table IV). The first accounted for 90.3% of the variance between the groups and contained skinfold and training variables. This again indicates the importance of these variables to success in distance running. Using the unstandardised coefficients, calculations to classify the runners into the three groups were made and indicated that the percentage of runners correctly classified was 96.7%.

TABLE IV

Statistical significant and standardised and unstandardised discriminant function coefficients

Variables	Standard-ised 1	Coefficients 2	Unstandard-ised 1[a]	Coefficients 2[b]
Height	0.07	−0.62	0.01	−0.10
Total skinfold	−0.06	−0.02	−0.20	−0.06
% Long runs	−0.04	1.13	−0.04	0.11
% Fast runs	0.02	1.17	0.00	0.15
% Interval runs	0.19	0.78	0.02	0.08
Sessions per week	0.61	0.54	0.48	0.42
Miles run per week	0.27	−0.80	0.03	−0.08
Constant			1.42	8.85

[a] Wilks Lambda = 0.05 (Chi-squared = 161.7, df = 14, $P < 0.000$) accounting for 90.3% of variance between groups
[b] Wilks Lambda = 0.51 (Chi-squared = 36.9, df = 6, $P < 0.000$) accounting for 9.7% of variance between groups

To summarise, statistical examination of the data supports the view that the better 10km distance runners have low skinfold measurements and are lighter and more linear, they train more regularly, run a greater mileage per week and have been running longer than less able performers.

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BOOK REVIEW

Title: **THE KNEE JOINT**
Author: Philip J. Evans
Publisher: Churchill Livingstone, Edinburgh. 1986
Price: £5.95 188 pages with Index Many line drawings ISBN 0-443-03248-3

This is a pocket guide to the examination of the knee and according to its author, is designed for medical students and junior orthopaedic surgeons in training. Any author will sympathise with his comments about the time this book took to write but I am afraid I have to say he should have taken longer.

The first part of the book purports to describe the normal movements of the knee. The frequent quotes from major works are often so incomplete as to be incomprehensible in isolation and the absent labelling of the majority of the diagrams renders them valueless. In the section on the clinical examination, there are so many errors of fact that they cannot be put down to sloppy proof reading, which is however also in evidence. This is perhaps best illustrated by the claim that the direction of abnormal movement in the positive Mackintosh test is anterior whereas it is in fact posterior. It is this reviewer's view that the book requires extensive revision.

J. B. King, FRCS

BOOK REVIEW

Title: **COMMON FOOT DISORDERS (2nd Edition)**
Editor: Donale Neale and Isobel Adams
Publishers: Churchill Livingstone
Price: £17.50 Soft cover ISBN 0-443-03285-8 Library of Congress Catalog No. WE 890 C734

The publication of the second edition of *Common Foot Disorders* has produced an update and expansion to a useful textbook. Practitioners involved in diagnosis and management of foot-related pathologies will find this text an essential first reference book. Sections on materials, pharmacology and clinical medicine have been revised to present current practice. New sections on clinical pharmacology, clinical therapeutics and sports injuries will give an insight into the changing structure and depth of chiropodial education and practice.

As with other texts covering many subjects, some areas are inadequately represented. Others are reinforced with good reference lists. Practical guidance on diagnosis, treatment and management is given to a greater or lesser degree.

Students of chiropody, podiatry and related professions, will find this book a useful guide to the study of common foot disorders.

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