

FITNESS TEST PROFILES AND TRAINING INTENSITIES IN SKILLED RACE-WALKERS

T. REILLY, BA, MSc, PhD, MIBiol, J. HOPKINS, BSc*,
and N. HOWLETT, BSc**

Department of Sport and Recreation Studies, Liverpool Polytechnic.

ABSTRACT

A broad profile of national standard race-walkers was obtained. Subjects were taller and had more body fat than competitive runners of comparable distance as found in the literature. Pulmonary function, blood pressure and maximal heart rates were similar to normal sedentary values. The group's somatotype was 2.5 : 3 : 4, low mesomorphy being reflected in inferior strength measures. Haematological status corresponded to the runners of Brotherhood et al (1975). Predicted $\dot{V}O_2$ max ($\bar{x} = 70 \text{ ml kg min}^{-1}$) was not related to performance. Time to exhaustion on a treadmill test correlated with 20 km race time ($R = -.94$; $p < .001$). Multiple regression equations derived to predict race performance from combinations of 4 to 6 personality traits were non-significant. Mean heart rate in typical training regimes was 167 beats min^{-1} for interval training at 13 kmh^{-1} on the track and 134 beats min^{-1} over a 2.1 h road walk at 10.3 kmh^{-1} . Physiological strain was greater in uphill than in level or downhill walking ($P < .001$).

KEY WORDS: *Fitness, Race-walking, Somatotype, Training.*

INTRODUCTION

A wealth of research effort has been spent in describing the characteristics of competitors in various endurance sports (for reviews see Åstrand and Rodahl, 1977; Carter, 1970; Costill, 1968; Ogilvie, 1968). Mostly investigations have tended to concentrate on top-flight performers in order to identify critical requirements for success and have described such characteristics in physical, physiological and psychological terms. This suggests that a holistic approach is appropriate in attempts to complete individual profiles and has demonstrated success in discriminating between proficiency levels, at least among endurance team players (Reilly and Thomas, 1977).

In individual locomotor sports a sensitive measure of performance proficiency is implicit in the time taken for the competitive event. Investigations of performance predictors have relied on studies of track, cross-country and road runners, which helps to explain the abundant data available on those athletes. In contrast little attention has been paid to race-walkers apart from the race-walkers included in the studies of discrete parameters by Forsberg and Lundin (1975), Saltin and Åstrand (1967) and Tanner (1964).

This study represents an initial attempt to provide basic data on broad profiles of a select group of race-walkers. These could serve as baseline to which later investigators could relate their results. It was hoped to

investigate relationships between selected fitness measures and competitive performance and additionally to obtain preliminary data on physiological strain in typical race-walking training regimes.

METHODS

Subjects were 25 top-class male race-walkers and included 14 members of the BAAB's national squad. Ages of subjects ranged from 16 to 33 (mean age 21.1) years. All subjects completed the EPPS personality questionnaire (Edwards, 1959) and provided details of their competitive performances at 3 km and 20 km. A fitness test battery comprising anthropometric, static and explosive strength, and circulatory measures was administered to fourteen of these subjects on attendance at the laboratory prior to the start of the competitive season. These had completed a background of endurance work over the winter and were considered to be of good fitness status for this seasonal phase.

Details of the tests and procedures are now provided.

Test Procedures

(a) *Anthropometric.* Height and weight were determined using a stadiometer mounted on a balance weighing scale. Subjects wore only athletic shorts during measurement. Body surface area (BSA) was estimated using the nomogram of Sendroy and Collison (1960). The values reported for leg length were estimates based on the difference between standing and sitting heights obtained according to Weiner and Louire (1969).

Vital Capacity (VC) and Forced Expiratory Volume

*National race-walking coach.

**Now at the Department of Physical Education, Leeds University.

in the first second of expiration (FEV_1) were determined using single breath dry spirometry. Peak Expiratory Flow (PEF) values were obtained using a Clement Clarke flowmeter.

Percentage body weight as fat was estimated from skinfold thickness at triceps, biceps, sub-scapular and supra-iliac sites using the method of Durnin and Womersley (1974). Skinfold fat was measured using a Harpenden skinfold caliper. Somatotype was determined using the Heath-Carter method (Carter, 1972).

(b) *Strength*. Grip strength of right and left hands was obtained using grip dynamometry. Back strength was measured using a Kyogo back dynamometer. Vertical jump and standing broad jump (SBJ) performance were employed as measures of explosive strength. These tests were conducted according to Clarke (1967) and the best of three trials was recorded in each case.

(c) *Circulatory measures*. Resting heart rate (fH) was obtained after 10 min lying supine on entering the laboratory and after procedures and the purpose of the study were briefly explained. Heart rate was obtained by palpation at the radial artery over 1 min and checked with duplicate measurements. Systolic and diastolic blood pressures (BP) were obtained using sphygmomanometry (Clarke, 1967). Haematological variables at rest pre-exercise were obtained on 6 of the 14 subjects. Haemoglobin concentration was determined by colorimetry. The erythrocyte count was obtained using a Naubauer chamber. Mean value of 3 heparinised capillary samples centrifuged for 5 min was taken as the haematocrit level.

Nine subjects underwent a continuous treadmill walk/run test to exhaustion. The test protocol was devised on the basis of empiric observations in a pilot study of race-walkers' behavioural responses to variations in speed and incline race-walking and running. A 10 min warm-up period of slow walking was permitted, followed by a 10 min rest prior to commencement of this test. The initial work load was set at a belt speed of 6 km h^{-1} and 1% slope and performed for 2 min. The speed was increased every 2 min by 2 km h^{-1} . After 6 min using a race-walking technique the subject then ran for 5 min without alteration of the work-load from 10 km h^{-1} and 1% slope. This correspond to Åstrand's (1953) sub-maximal work level for the prediction of VO_2 max from fH reaction. Treadmill speed was then increased by 1 km h^{-1} every 2 min up to a speed of 14 km h^{-1} . The incline was then increased every 2 min by 2%. The test was prolonged until the subject was unable to continue running. Heart rate was recorded using a Sanei electrocardiogram and chest head leads over the final 15s at each work level, and continuously once the maximal speed of 14 km h^{-1} was reached.

The variables extracted were:

- (i) predicted VO_2 max using Åstrand and Ryhming's (1954) method;
- (ii) maximal heart rate (fHmax), being the maximal value reached during the test;
- (iii) time to exhaustion being the duration of the treadmill test before the subject desisted.

Training

One subject was studied during a typical track and a road training session. The track regime was a standard intermittent work programme employed by international walkers and was conducted on a 400m lap tartan surface. Work periods alternated between 800m, 1000m, 1200m and 1600m efforts while recovery periods were consistently about 2 min. The road training consisted of a 2 h 6 min walk over country roads and varying terrain. Heart rate was used as the index of physiological strain during both track and road conditions and was monitored by radio telemetry (Parks NEC Type 101) over every 30s. The ECG receiver was carried in a following car during the road training session and a commentary recorded each time the terrain varied between uphill, downhill and level grade.

Statistical Analysis

Correlations between selected fitness items and race performances over 3 km and 20 km were investigated using the Pearson Product Moment method of correlation. The variables used were percent body fat, predicted VO_2 max and treadmill run time. A multiple regression technique was employed to derive prediction formulae for 3 km and 20 km times using combinations of 4 to 6 personality variables.

In analysis of the training data multiple t tests were used to investigate differences between work periods in order to determine the existence of trends in heart rate throughout the track session (Senter, 1969). A similar procedure was used in analysis of the recovery periods. Work period mean heart rates were correlated with the distance covered and with the subsequent mean heart rate during recovery using the method of Pearson.

Heart rate data during the road session were divided into successive 15 min periods and a completely randomised ANOVA (Senter, 1969) used on the seven treatment levels to investigate differences between periods for any significant trend in heart rate throughout the session. Additionally differences in mean heart rate during uphill, downhill and level grade walking were studied using t tests.

A level of probability of 5% was accepted as indicating statistical significance in the analyses.

TABLE I:

Mean \pm SE of selected anthropometric, strength and circulatory measures of race-walkers (n = 14)

| Anthropometry | | Strength | | Circulatory Measures | |
|-------------------------------------|-----------------|----------------------|--------------|--|-----------------|
| Height (cm) | 180.4 \pm 2 | Grip Right Hand (kg) | 43 \pm 1.5 | Systolic BP (mmHg) | 130.5 \pm 3 |
| Weight (kg) | 66.2 \pm 1.6 | Grip Left Hand (kg) | 42 \pm 2 | Diastolic BP (mmHg) | 82 \pm 3 |
| Body Surface Area (m ²) | 1.80 \pm 0.03 | Back (kg) | 128 \pm 6 | Resting fH (beats/min ⁻¹) | 63 \pm 3 |
| Leg length (cm) | 87 \pm 1 | Vertical Jump (cm) | 42 \pm 2 | fHmax (beats min ⁻¹) | 194 \pm 3 |
| Body Fat (%) | 11.6 \pm 0.7 | SBJ (cm) | 193 \pm 6 | Predicted $\dot{V}O_2$ max (L/min ⁻¹) | 4.7 \pm 0.2 |
| Endomorphy | 2.5 \pm 0.2 | | | Predicted $\dot{V}O_2$ max (ml/kg/min ⁻¹) | 70 \pm 3 |
| Mesomorphy | 3 \pm 0.2 | | | Haemoglobin (g/dL) | 13.9 \pm 0.5 |
| Ectomorphy | 4 \pm 0.3 | | | Erythrocyte count (10 ⁶ /mm ⁻³) | 5.04 \pm 0.24 |
| Vital Capacity (L - BTPS) | 5.4 \pm 0.2 | | | Haematocrit (%) | 43.3 \pm 1.5 |
| FEV ₁ (L - BTPS) | 4.6 \pm 0.2 | | | | |
| PEF (L/min ⁻¹) | 587 \pm 52 | | | | |

RESULTS

Mean and standard error of anthropometric, strength and circulatory measures are summarised in Table I. The distribution of individual somatotypes is shown in Figure 1. Mean heart rate responses at each stage of the treadmill test are shown in Table II. These include walking and running, speed and grade increment stages. Results showed a linear relationship between work level and heart rate with different slopes for the speed and grade increment stages until a levelling off in heart rate occurred near maximal level.

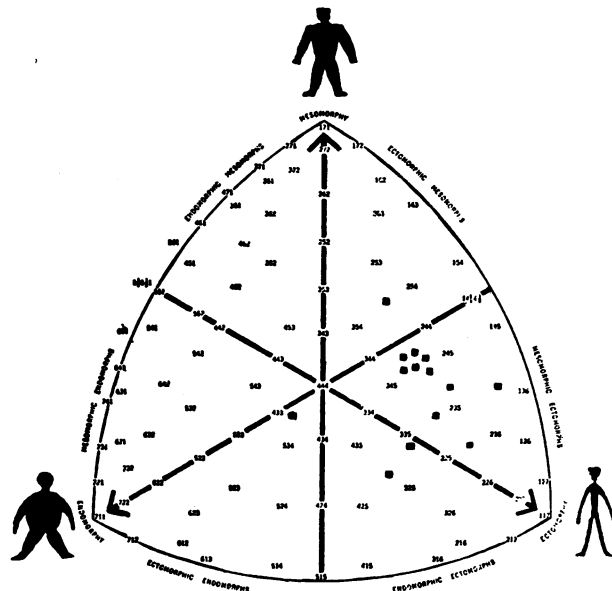


Figure 1: Somatochart of national road walking squad members (n = 14)

Percent body fat was not significantly correlated with predicted $\dot{V}O_2$ max or with competitive performance.

TABLE II:

Heart rate responses at successive stages in the treadmill walk/run test (n = 9)

| Work stage | Speed (km h) | Incline (%) | Heart Rate beats min ⁻¹ ($\bar{x} \pm$ SE) |
|------------|--------------|-------------|--|
| 1 | 6 | 1 | 95 \pm 3 |
| 2 | 8 | 1 | 113 \pm 4 |
| 3 | 10 | 1 | 131 \pm 4 |
| 4* | 10 | 1 | 133 \pm 4 |
| 5 | 11 | 1 | 145 \pm 4 |
| 6 | 12 | 1 | 152 \pm 4 |
| 7 | 13 | 1 | 159 \pm 4 |
| 8 | 14 | 1 | 167 \pm 3 |
| 9 | 14 | 3 | 173 \pm 3 |
| 10 | 14 | 5 | 178 \pm 3 |
| 11 | 14 | 7 | 183 \pm 4 |
| 12** | 14 | 9 | 188 \pm 3 |
| 13 | 14 | 11 | 190 \pm 3 |
| 14*** | 14 | 13 | 197 \pm 13 |

* Stages were of 2 min duration, except for 5 min run at Stage 4. The work mode was walking at previous stages and running in all subsequent ones.

** 2 subjects desisted at this stage.

*** Only 3 subjects commenced this stage.

Time over 20 km was not significantly correlated with predicted $\dot{V}O_2$ max (ml/kg/min⁻¹) ($R = .53$) but was significantly correlated with time on the treadmill test ($R = -.94$; $p < .001$). This correlation was not found with performance at 3 km. The mean time to exhaustion on the treadmill test was 28.16 min.

The personality assessment showed that mean values were high for the traits of achievement, autonomy, dominance, heterosexuality and aggression. Mean values were low for deference, affiliation and succorance. Variance was highest for achievement, heterosexuality

and dominance. Multiple regression equations derived to predict performance using combinations of 4 to 6 traits for 3 km and 20 km were non-significant. Correlational analysis identified some significant relationships between variables – nurturance and achievement ($R = -.59$; $p < .05$), exhibition and order ($R = -.55$; $p < .05$), nurturance and affiliation ($R = .62$; $p < .01$), succorance and dominance ($R = .54$; $p < .05$).

The track interval training session was preceded by a warm up lasting 11 min during which mean fH was 123 beats min^{-1} , the intensity and duration being spontaneously determined by the subject. Mean fH during the pooled work periods was 167 beats min^{-1} and during the recovery period which averaged 1.92 min duration was 139 beats min^{-1} . Resting and maximal heart rates of the subject were 48 and 186 beats min^{-1} . The mean velocity of walking during the work period was 13 km h^{-1} . No significant trend was found in the work or recovery mean fH values with duration of training or with the distance of the work period.

The training session on the road was conducted at a mean velocity of 10.3 km h^{-1} . Mean fH over this session was 134 beats min^{-1} . The ANOVA showed no significant difference between the 15 min periods indicating a roughly constant heart rate throughout the session. Mean and standard deviation for each 15 min period are shown in Figure 2. Mean fH for the uphill terrain was 144 beats min^{-1} and was significantly different ($p < .001$) from level (mean 132; SE 0.5 beats min^{-1}) and downhill walking (mean 131; SE 1.4 beats min^{-1}). The difference between level and downhill mean rates was non-significant.

DISCUSSION

When compared with values for marathon (Costill and Fox, 1969), cross-country (Costill, 1967) and track runners (Novak et al, 1968) it would seem that walkers are intermediate in height and weight between distance runners on the one hand and middle-distance and sprint men on the other. The group in the current study had greater linear measurements than the six Olympic walkers of similar weight studied by Tanner (1964). The difference might be accounted for by the higher mesomorphy in the Olympic walkers. The majority still bordered the north-eastern section of the somatochart where most Olympic Games males are located. The poor strength and jump performances when compared with other international endurance sportsmen (Costill, 1967; Ishiko, 1974) may reflect imperfect muscular development or be the outcome of training regimes biased towards endurance work.

The mean percent body fat of 11.6% is lower than the normal 15% for men in their twenties (Durnin and

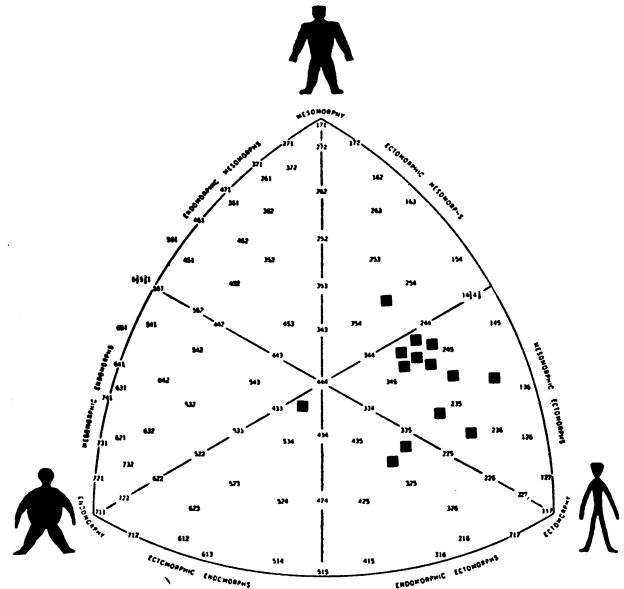


Figure 2: Heart rate ($\bar{x} \pm S.D.$) for successive 15 min periods of the prolonged training sessions on road.

Womersley, 1974) and the reported figures for American football and baseball players (Novak et al, 1968). Subjects had more relative fat than cross-country runners (Costill and Fox, 1969; Sprynarova and Parizkova, 1971) and the 7.5% found in marathon runners (Costill et al, 1970). The excess mass as fat is unlikely to be as disadvantageous as in running where body weight is raised vertically to an appreciable degree.

Lung function results were similar to expected values for normal males of similar age and size (Garbe and McDonnell, 1964; Leiner et al, 1963) but lower than figures for professional soccer players of smaller stature (Reilly and Thomas, 1977a). It seems that in single breath spirometric measures race-walkers are indistinguishable from non-athletes. Blood pressures were within the normal range, both systolic and diastolic being higher than values reported for relaxed elite endurance athletes (Costill, 1967; Novak et al, 1968). Similarly resting heart rates did not exhibit pronounced training bradycardia. Apprehension induced by awareness of impending testing could have been reflected in these values. The maximal heart rates of 194 beats min^{-1} also agreed with expected values for male subjects of similar age (Åstrand, 1952).

Haematological data were close to normal apart from haemoglobin concentration which was 1.9 g/dL below the mean value for adult males quoted by Åstrand and Rodahl (1977). The finding in this study was close to the 14.16 g/dL observed by Brotherhood et al (1975) in

runners and may reflect the greater control of the viscera over mobilisation of blood cells in athletes at rest. Since total body haemoglobin and 2,3 DPG have been found to discriminate between athletes and non-athletes, the haematological status of top race-walkers merits further investigation, particularly with regard to blood volume and intermediates in oxygen transfer. The estimated $\dot{V}O_2$ max mean values of 4.7 L min^{-1} and $70 \text{ ml kg min}^{-1}$ were practically identical to the measurements obtained on Swedish internationals (Saltin and Åstrand, 1967; Forsberg and Lundin, 1975). Failure to replicate the much cited negative correlation between $\dot{V}O_2$ max and both percent body fat and competitive performance time (e.g. Åstrand and Rodahl, 1977; Novak et al, 1968) may suggest error variance in inter-group variability when estimates are employed. The measurement error associated with the Åstrand – Ryhming nomogram is known to be reduced when trained athletes are used (Koeslag and Sloan, 1976).

The higher heart rates found for running at the treadmill velocity common to both modes suggest that the point at which running becomes the more efficient method of locomotion may be higher than the 8 km h^{-1} found by Margaria et al (1963) for normal walking and the 8.25 km h^{-1} reported by Menier and Pugh (1968) for race-walkers at altitude. The highly significant correlation between time to exhaustion and 20 km performance suggests the potential of this treadmill test for predictive purposes. Its advantage is probably its greater affinity to competitive performance than predicted $\dot{V}O_2$ max though $\dot{V}O_2$ max should be measured for a comprehensive fitness profile.

Failure to derive significant predictive formulae from the EPPS traits does not call for abandonment of psychological screening in assessing sportsmen. Personality testing has demonstrated efficacy in discriminating between different athletic groups and proficiency levels (Kane, 1968; Ogilvie, 1968). Its main utility with elite athletes may be in assisting to formulate interpersonal coaching techniques.

The mean fH during work periods on the track of $167 \text{ beats min}^{-1}$ was evidence of the intensive nature of this type of training. This value was 7 beats min^{-1} higher than that reported for continuous race-walking at a velocity 1 km h^{-1} slower (Forsberg and Lundin, 1975), and was within $19 \text{ beats min}^{-1}$ of the subject's fH max. Absence of a significant trend as the session advanced suggested the subject accurately paced himself through the session. The intensity for level walking on the road of $134 \text{ beats min}^{-1}$ closely corresponded with the $131 \text{ beats min}^{-1}$ for the group at the treadmill speed of 10 km h^{-1} and 1% slope. The effect of air resistance in the outdoor condition did not seem to have been pronounced. The work level probably lay above the training stimulus threshold (Karvonen et al, 1957), particularly when uphill walking was involved. Road training routes could be strategically selected to include frequent uphill sections to accentuate the physiological strain during long walks. An alternative method of enhancing the training stress would be to increase the velocity of walking to approximate competitive walking pace. This type of regime when included in the training schedule would be performed for a reduced duration, though some long duration walks should still be retained.

REFERENCES

- Åstrand, P. O. 1952. "Experimental studies of physical working capacity in relation to sex and age". Munksgaard, Copenhagen.
- Åstrand, P. O. 1953. "A study of capacity for hard muscular work of 17 to 19 year old male youths". *Arbeitsphysiologie* 15: 251-254.
- Åstrand, P. O. and Ryhming, I. 1954. "A nomogram for calculation of aerobic capacity (physical fitness) from pulse rate during sub-maximal work". *J.Appl.Physiol.* 7: 218-221.
- Åstrand, P. O. and Rodahl, K. 1977. "Textbook of work physiology". McGraw-Hill, New York.
- Brotherhood, J., Brozovic, B., and Pugh, L. G. C. 1975. Haematological status of middle and long distance runners." *Clin.Sci.* 48: 139-145.
- Carter, J. E. L. 1970, "The somatotype of athletes – a review". *Human Biology*, 42: 535-569.
- Carter, J. E. L. 1972. "The Heath-Carter somatotype method". San Diego State College, San Diego.
- Clarke, H. H. 1967. "Application of measurement to health and physical education". Prentice-Hall, New Jersey.

- Costill, D. L. 1967. "The relationship between selected physiological variables and distance running performance". *J. Sports Med. & Phys.Fit.* 7: 61-66.
- Costill, D. L. 1968. "What research tells the coach about distance running". AAHPER, Washington.
- Costill, D. L. and Fox, E. L. 1969. "Energetics of marathon running". *Med.Sci.Sports* 1: 81-86.
- Costill, D. L., Bowers, R., and Kammer, W. F. 1970. "Skinfold estimates of body fat among marathon runners". *Med.Sci.Sports* 2: 93-95.
- Durnin, J. V. G. A., and Womersley, J. 1974. "Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged 16 to 72 years". *Brit.J.Nutr.* 32: 77-97.
- Edwards, W. L. 1959. "Personal preference schedule manual". The Psychological Corporation, New York.
- Forsberg, A., and Lundin, A. 1975. *Idrottsfysiologi Rapport nr 15*. Trygg Hansa, Stockholm.
- Garbe, D. R., and McDonnell, H. 1964. "Lung function testing: an introduction to routine clinical tests illustrated with the use of the vitalograph". Vitalograph Ltd., Buckingham.
- Ishiko, T. 1974. "The organism and muscular work". In *Fitness, health and work capacity* (L. A. Larson, Ed.). Macmillan, New York.
- Kane, J. E. 1968. "Personality and physical abilities". Paper presented to the International Congress of Sports Psychology (Washington).
- Karvonen, M. J., Kentala, E., and Mustala, O. 1957. "The effects of training on heart rate". *Ann.Med.Exer.Biol.Fenn.* 35: 307-315.
- Koeslag, J. H., and Sloan, A. W. 1976. "Maximal heart rate and maximal oxygen consumption of long distance runners and other athletes". *J.Sports Med.& Phys.Fit.* 16: 17-21.
- Leiner, G. C., Abramowitz, S., Small, M. J., Stenby, V. B., and Lewis, W. A. 1963. "Expiratory peak flow rate. Standard values for normal subjects. Use as a clinical test of ventilating function". *Amer.Rev.Resp.Dis.* 88: 644.
- Margaria, R., Ceretelli, P., Aghemo, P., and Sassi, G. 1963. "Energy cost of running". *J.Appl.Physiol.* 18: 367-370.
- Menier, D. R., and Pugh, L. G. C. E. 1968. "The relation of O₂ intake and velocity of walking and running in competition walkers". *J.Physiol.* 197: 717-721.
- Novak, L. P., Hyatt, R. E., and Alexander, J. F. "Body composition and physiological function of athletes". *J.Amer.Med.Ass.* 205: 764-770.
- Ogilvie, B. C., 1968. "Psychological consistencies within the personality of high level competitors". *J.Amer.Med.Ass.* 205: 780-786.
- Reilly, T., and Thomas, V. 1977. "Applications of multivariate analysis to the fitness assessment of soccer players". *Brit.J.Sports Med.* 11: 183-184.
- Reilly, T. and Thomas, V. 1977a. "Effects of a programme of pre-season training on the fitness of soccer players". *J.Sports Med.& Phys.Fit.* 17: 401-412.
- Saltin, B., and Åstrand, P. O. 1967. "Maximal oxygen uptake in athletes". *J.Appl.Physiol.* 23: 347-352.
- Sendroy, J. Jr. and Collison, H. A. 1960. "Nomogram for determination of human body surface area from height and weight". *J.Appl.Physiol.* 15: 958-959.
- Senter, R. J. 1969. "Analysis of data. Introductory statistics for the behavioural sciences". Scott, Foresman and Co., Illinois.

Sprynarova, S. and Parizkova, J. 1971. "Functional capacity and body composition in top weight-lifters, swimmers, runners and skiers". *Int.Z.angew.Physiol.* 29: 184-194.

Tanner, J. M. 1964. "The physique of the Olympic athlete". George Allen and Unwin, London.

Weiner, J. S., and Louire, J. A. 1969. "Human biology: a guide to field methods". Blackwell, Oxford.

MEETINGS OF OTHER ORGANISATIONS

SPORTS INJURIES

One Day Instructional Course

The Institute of Accident Surgery are holding a one day instructional course on sports injuries at the University of Birmingham on

FRIDAY, 21st SEPTEMBER, 1979

The course is aimed at a level of registrars in surgery and medicine but should be of value to physiotherapists and remedial gymnasts with an interest in the subject. A series of lectures and demonstrations will be followed by the course dinner (included in the course fee).

Speakers include:

Dr. I. D. Adams, MD, Mr. J. Buck, FRCS, Mr. J. Kenwright, FRCS, and Mr. N. Tubbs, FRCS

Course Fee £20

Applications and enquiries should be addressed to:

**Mrs. D. Steele, Conference Organiser,
86 Black Haynes Road,
Birmingham B29 4QN
Tel: 021 475 6299**

Closing date of acceptance to dinner: Saturday, 1st September, 1979