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FITNESS ASSESSMENT OF ENGLISH LEAGUE SOCCER PLAYERS THROUGH THE COMPETITIVE SEASON

V. THOMAS, DLC, PhD and T. REILLY, PhD, MIBiol.

Department of Sport and Recreation Studies, Liverpool Polytechnic

ABSTRACT

A battery of 26 tests was administered to professional soccer players (n=31) at 3 points during the competitive season. Significant changes from start to mid-season were limited to improved muscular power, increased resting heart rate (fH), decreased force expiratory flow (FEF) and ankle mobility. No further changes with the duration of the competitive season were observed. Differences between squads were predominantly cardiac function measures at mid-season, and strength, muscular power and limb girths at the end of the season. The First Team squad had consistently less fat and poorer ankle mobility. It seems that mean fitness levels remain relatively stable during the playing season, though the measures significantly discriminating between the top and reserve squads fluctuate.

INTRODUCTION

Appreciable research effort has been spent on the study of seasonal variation in fitness levels of sportsmen. Some studies have concentrated on physiological effects over a period of intensive training such as occurs with strenuous conditioning programmes prior to the commencement of the competitive season (eg Reilly and Thomas, 1977). Alternatively other investigators have attempted to measure detraining effects once the final competitive event for the year has taken place (Fardy, 1969). Both approaches have been primarily concerned with establishing the magnitude of changes occurring at the start and end of the athletes' annual cycle.

Additionally the monitoring of fitness levels throughout the competitive season has proved attractive to research workers. The objective has been to identify whether the training status deteriorates, improves or is maintained during this period in the sport group in question. This then serves as an evaluation of training methods employed. Groups observed have included track and field athletes (Thomas and Reilly, 1976), swimmers (Bachman and Horvath, 1969), speed canoeists (Cermak, Kuta et al, 1975), basketball players (Coleman, Kreuzer et al, 1974), skiers (Hanson, 1975), American college footballers (Thompson, 1959) and rowers (Wright, Bompa et al, 1976). Results suggest that training effects in this period differ between sports and level of competition. It seems also that the effectiveness of the pre-season conditioning programme influences the acquisition of subsequent training states.

This investigation is concerned with professional soccer players in the English League, whose competitive season generally extends for longer than that of most sports hitherto examined. The effects of a six-week period of conditioning prior to the first League match of the season were reported earlier (Reilly and Thomas, 1977). Significant training effects were confined to improvements in the circulatory system accruing from a bias of endurance work. The current purpose was to monitor fitness levels in soccer players throughout a complete competitive season.

METHODS

Subjects

Thirty-one players constituting the complete playing staff of an English League First Division club acted as subjects. The mean age at the commencement of the competitive season was 22.6 (range 18-29) years. A test battery embracing 26 test items was administered during the week prior to the commencement of the League season (T1). Tests were repeated after an interval of 16 weeks (T2), the timing being taken as representative of mid-season, and again 21 weeks later (T3) after the final match of the playing season. On each occasion the First Team and Second Team squads were tested on separate but successive days. One subject at T2 and three at T3 could not participate in the tests due to injury.

Procedures

Tests were conducted according to standardised procedures (Weiner and Louire, 1969). The 26 test items included 17 anthropometric and blood pressure variables. Four tests of muscular strength and power employed grip dynamometry and standing broad and vertical jump performances (Clarke, 1967). Five measures of cardiac function included resting and maximal heart rate (fH), a cardiac assessment factor (CAF) determined according to Thomas (1973), the Harvard Index (Brouha, 1943), and heart rate (fH) response after 5 min treadmill running at 10 km/h^{-1} and 1% slope (Åstrand, 1953).

Statistical Analysis

Mean and standard deviation were calculated for each variable for the complete group tested at each stage. A series of ANOVAs was carried out to investigate both differences between the First Team and Second Team squads and differences between tests. Two composite variables were included in the ANOVA, summated fatfolds and pulse pressure. Separate analyses were employed for T1/T2 and T2/T3 investigations to allow for any changes in squad composition in the interim. In effect 28 separate ANOVAs were used to investigate changes between T1 and T2. A further 28 analyses were employed for T2/T3 comparisons while all 56 tests incorporated comparisons between the two squads. A level of probability of 5% was accepted as indicating a significant difference.

To highlight the examination of squad separability a series of discriminant function analyses was performed. This involved separate analysis of (i) the pooled anthropometric and blood pressure data, (ii) strength and power variables, (iii) cardiac function items, for each seasonal phase. Rao's f test and Bartlett's chi squared test were used as tests of significance (Jones, 1964).

The competitive season

The League season for the year of the investigation extended for 37 weeks. During this time the First Team contested 42 League matches, 3 Cup matches and 3 friendly or testimonial games. In a typical week training was undertaken on 5 days, the mean duration of a session being 75 min.

RESULTS

Means and standard deviations for test variables for the three test administrations are presented in Table I. Vital capacity (VC) and forced expiratory volume in 1 sec (FEV_1) at the first test (T1) were each significantly greater than values predicted from height and age of subjects using a standard nomogram (Garbe and McDonnell, 1964) ($p < .001$). The mean difference between observed and predicted values at this stage was 0.7 L. Ankle mobility measures at T1 corresponded to normal values for adult male subjects (Nowak, 1972). Reaction times were faster than normal values quoted for visual reaction time and for track and field athletes at club level (Thomas and Reilly, 1976). Grip strength values were close to those reported for non-athletic adult male subjects (Ishiko, 1974).

The blood pressure measures suggested normal systolic values but reduced diastolic pressures when compared with data reported for the general population. Resting heart rates at T1 were well below normal values or the 59 beats/min^{-1} reported for Roumanian soccer players (Balanescu, Vokulescu et al, 1968). Maximal heart rates were in close agreement with normal values for European men (Åstrand and Rodahl, 1977). Scores on the Harvard Step tests merited classification as excellent on the norms prepared for college students but were well below those recorded for soccer players at Olympic Games (Ishiko, 1967).

Results of the ANOVA tests are summarised in Table II. The variance between subjects accounted for a significant proportion of the total variance in 17 of the 28 variables in the T1/T2 analyses and in 16 of these in the T2/T3 analyses ($p < .05$). The comparison between tests indicated that standing broad jump (SBJ) and resting fH increased significantly between T1 and T2 ($p < .01$) and that FEF and ankle mobility decreased over this time ($p < .01$). None of the variables showed a significant change between T2 and T3.

The First Team squad as constituted at T1 had significantly higher values for systolic and diastolic blood pressures, vertical jump and SBJ.

Differences between squads were significant in analysis of the T1/T2 data for triceps fat ($p < .05$), ankle mobility ($p < .01$), resting fH ($p < .01$), treadmill run fH ($p < .01$), the Harvard Index ($p < .01$), maximal fH ($p < .05$) and CAF ($p < .05$). The First Team squad had the higher values for the Harvard Index and CAF, and the lower values for triceps fat, ankle mobility, resting fH, maximal fH and treadmill run fH. Inter-squad differences in the T2/T3 analyses were significant for summated fatfolds ($p < .05$), arm girth ($p < .05$), chest girth (deflated) ($p < .05$), ankle mobility ($p < .01$), left hand grip strength ($p < .01$), vertical jump ($p < .01$) and SBJ ($p < .05$). The First Team had the higher mean values for arm and chest girth, left hand grip, vertical jump and SBJ and the lower figures for ankle mobility and summated fatfolds. The interaction term was significant for SBJ at T1/T2 ($p < .01$), no further interactions being significant in any of the analyses.

Results of the discriminant function analyses are summarised in Table III. Results were non-significant for strength and power and the anthropometry set for the three test administrations ($p > .05$). The cardiac function measures successfully discriminated between squads at mid-season only ($p < .05$).

DISCUSSION

Several authors have reported previously that pulmonary function measures are superior in athletes compared with non-athletes (eg Kroll, 1954; Stuart and Collings, 1959). Alternatively this superiority over normal values has not been shown in some sports groups eg in race-walkers (Reilly, Hopkins et al, 1979) or in Dallas Tornado soccer players (Raven, Gettman et al, 1976). The Dallas Tornado players were on average of similar height and 2.4 kg heavier but had mean VC values 0.6 L lower than current subjects. Since it seems VC can be enlarged significantly as a result of long-term training over a number of years (Bock, 1963), the high values in the subjects studied here may be attributable to the

TABLE I

Anthropometry and resting blood pressure, strength and muscular power, and cardiac function data for professional soccer players at various stages of the competitive season (mean ± standard deviation)

	Variable	START of competitive season (T1)	Mid season (T2)	END of season (T3)
		n = 31	n = 30	n = 28
	Anthropometry			
1.	Height (cm)	176 ± 6	176 ± 6	177 ± 6
2.	Weight (kg)	73.3 ± 7.9	73.3 ± 8.3	74.7 ± 8.7
3.	VC (L)	5.9 ± 0.9	5.7 ± 0.9	6.0 ± 0.9
4.	FEV_1 (L)	5.0 ± 0.8	4.85 ± 0.7	5.05 ± 0.8
5.	Forced expiratory flow (L/s)	10.6 ± 1.8	9.3 ± 1.8	9.3 ± 1.9
6.	Triceps fat (mm)	8.3 ± 2.8	8.1 ± 2.3	8.1 ± 3
7.	Subscapular fat (mm)	8.5 ± 2.5	8.5 ± 2.3	8.2 ± 2.2
8.	Supra-iliac fat (mm)	8.8 ± 3.9	8.6 ± 4	9.3 ± 4
9.	Chest deflated circumference (cm)	91 ± 4.5	90 ± 4.9	91 ± 5
10.	Chest inflated circumference (cm)	97 ± 4.4	97 ± 4.6	98 ± 5
11.	Arm girth (cm)	31 ± 2.1	31 ± 2.1	31 ± 4.8
12.	Thigh girth (cm)	55 ± 3.2	57 ± 5	56 ± 3.9
13.	Calf girth (cm)	37 ± 1.9	37 ± 2	37 ± 2.2
14.	Ankle mobility (°)	61 ± 7.4	55 ± 7.6	54 ± 6.5
15.	Reaction time (ms)	149 ± 14	150 ± 18	148 ± 18
	Blood Pressure			
16.	Systolic blood pressure (mm Hg)	120 ± 12	122 ± 14	119 ± 5
17.	Diastolic blood pressure (mm Hg)	66 ± 11	70 ± 10	65 ± 11
	Muscular Strength and Power			
18.	Grip (Right hand) (kg)	49.1 ± 6.6	47.8 ± 6.4	47 ± 6.7
19.	Grip (Left hand) (kg)	47.7 ± 6.2	47.2 ± 5.6	45.6 ± 6
20.	Vertical jump (cm)	55.6 ± 6	54 ± 6.3	54.3 ± 7
21.	Standing broad jump (cm)	211 ± 17.4	225 ± 11.6	225 ± 15.2
	Cardiac function			
22.	Resting fH (beats/min^{-1})	54 ± 9.6	65 ± 14.2	59 ± 8.3
23.	Treadmill run fH (beats/min^{-1})	132 ± 14.4	137 ± 15.2	139 ± 13.4
24.	Harvard Index	99.5 ± 12.3	97.6 ± 14.3	96.9 ± 12
25.	fH max (beats/min^{-1})	196 ± 12.6	195 ± 19.8	196 ± 11.2
26.	CAF	41.8 ± 6.7	41.4 ± 5.4	39.9 ± 5.4

quality of their habitual regime over their professional lives. Several studies however have found no improvements in lung function measured in single maximal breaths with intense short-term training (Adams, 1968; Thomas and Reilly, 1976), though significant changes have been reported in swimmers (Bachman and Horvath, 1969) and wrestlers (Shaver, 1974) over a four month period. No seasonal variations were evident in the present investigations, so that the degree to which the consistently high lung function values resulted from prolonged earlier training or from endowment must remain speculative. The significant change in FEF between T1 and T2 was not supported by the FEV_1 findings and since these measures are usually significantly correlated was unlikely to have represented an effective loss in lung power.

The observations suggested that footballers are not supranormal in ankle joint mobility. The normal values may be due to the relative inattention to flexibility routines in the training programme of English League professionals (Adams, 1971). The deterioration from the start of the season was not anticipated and the finding of superior values among the Second Team squad was

TABLE II

Results of ANOVA tests T1/T2 and T2/T3. Variance Ratios

Variable	Between Subjects		Between Squads		Between Tests	
	T1/T2	T2/T3	T1/T2	T2/T3	T1/T2	T2/T3
Height	2.46*	3.36**	0.01	3.84	0.03	0.14
Weight	2.62*	1.89	0.93	2.82	0.11	0.002
VC	2.48*	7.89**	2.60	0.04	0.28	3.70
FEV_1	2.70*	9.99**	0.75	0.01	1.32	1.37
FEF	1.31	2.25*	1.77	0.13	7.65**	0.69
Triceps fat	9.77**	1.83	7.15*	2.53	0.48	0.49
Subscapular fat	5.11**	2.19*	1.88	3.98	0.01	0.22
Supra-iliac fat	5.06**	3.42**	3.94	4.02	0.30	0.29
Summated fatfolds	7.85**	2.63*	2.86	4.55*	0.002	0.09
Chest deflated	1.21	1.62	2.41	5.07*	0.03	0.09
Chest inflated	1.15	2.70*	0.25	3.55	0.32	0.12
Arm girth	1.93	1.71	0.58	5.53*	0.12	0.01
Thigh girth	2.23*	0.49	2.68	2.80	0.53	0.01
Calf girth	3.09**	5.63**	0.67	3.54	0.000	0.000
Ankle mobility	1.71	1.38	21.06**	12.81**	19.15**	0.84
Reaction time	0.52	1.33	4.02	1.14	0.004	1.84
Systolic BP	1.18	0.95	0.14	0.37	0.60	0.81
Diastolic BP	0.73	1.06	0.39	2.87	1.36	2.96
Pulse pressure	6.00**	1.10	0.01	0.44	0.004	0.13
Grip right hand	2.72*	2.64*	2.75	1.14	0.34	0.95
Grip left hand	1.75	3.95**	1.49	8.10**	0.001	1.98
Vertical jump	1.82	1.47	0.95	21.86**	1.45	0.12
SBJ	4.21**	2.57*	3.71	7.26*	24.86**	0.07
Resting fH	3.52**	5.45**	19.46**	0.001	12.65**	0.58
Treadmill run fH	2.91**	2.27*	11.04**	0.42	2.28	0.29
Harvard Index	2.27	1.60	24.13**	0.29	0.40	0.05
fH max	2.51*	3.20**	5.90*	0.17	0.64	0.29
CAF	3.01**	4.75**	6.00*	0.46	0.17	2.65

*Denotes $P < .05$ **Denotes $P < .01$

TABLE III

Summary of results of discriminant function analysis tests

	Number of variables	Test administration	Rao's F Test (F Ratio)	Bartlett's chi-squared	Probability Level
Strength and Power	4	T1	1.28	4.85	$p > .10$
	4	T2	1.55	5.77	$p > .10$
	4	T3	1.41	5.26	$p > .10$
Anthropometry	17	T1	1.81	24.57	$p > .10$
	17	T2	0.68	13.15	$p > .10$
	17	T3	2.13	26.80	$p > .05$
Cardiac Function	5	T1	0.81	3.96	$p > .10$
	5	T2	3.85	15.02	$p < .05$
	5	T3	0.69	3.42	$p > .10$

contrary to expectations. It is possible that this function was affected at T2 and T3 by residual stiffness resulting from strenuous Football League competition 42 h before testing in each instance. Alternatively it may be that joint stiffness is aggravated during the competitive season and becomes more pronounced with experience in the game, the First Team members being on average 3.3 years older than their Second Team counterparts.

The lower fatfold values in the top squad would indicate a more favourable body composition for endurance performance, since excess mass as fat is disadvantageous where it must repeatedly be lifted against gravity as in soccer play. The higher girth measures in the First Team at the end of the season suggest that the more robust individuals survived the rigours of the prolonged competitive programme better. The greater performances in strength and power tests similarly indicate the more successful squad had greater muscularity. As strength is related to muscle cross-sectional area, training regimes for muscular development would seem to be important for maintaining top-level performance in this sport. This is supported by a previous finding that an array of isometric strength (determined by cable tensiometry) and explosive strength measures successfully discriminated between different soccer proficiency levels (Reilly and Thomas, 1977a). Strength measures in the current study were limited to grip dynamometry. Distinction between squads on the basis of strength and power and anthropometric data sets was not significant. Successful squad separation using a group of variables considered as a whole is likely to be hampered as the competitive season progressed by the intervention of nuisance variables such as injury or mobility between squads arising from related contingencies.

Performance in standing broad jump (SBJ) improved once the competitive season was underway. It seems that the bias in endurance training in the pre-season conditioning period resulted in many players commencing the competitive programme with sub-optimal levels of muscular power and strength in various muscle groups (Reilly and Thomas, 1977). Present observations suggest this deficit is made good during the competitive season while circulatory measures remain relatively stable. The tachycardia found in mid-season was possibly emotional in origin, since test administration coincided with a sequence of poor Football League match results. The consistently high pulse pressures indicated that the circulatory entraining possessed at the start of the season was probably retained. The cardiac function measures as a whole successfully separated the two squads only in mid-season. Since both squads undertook common physical training regimes prior to the start of the League programme differences were not likely as a result. The superior fitness measures in the First Team squad in mid-season may have been attributable to the higher physiological stimulus presented partly by League competition and by training in that squad or could be the result of a consistent run unimpaired by injury which usually involves relegation to the Second Team squad. Maximal fH has frequently been found to drop with exposure to certain training routines (Ekblom, 1969) due to a reduced drive from the sympathetic system to the heart with conditioning, the lower values in the top squad further supporting the enhanced training status of this group, given these training routines. It appears that distinction between squads on the basis of cardiac function tests became blurred by the end of the season, as exigencies in the latter part of the season compelled recruitment of players with inferior circulatory efficiency to the League Team.

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