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A multidisciplinary approach to talent identification in soccer

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The requirements for soccer play are multifactorial and distinguishing characteristics of elite players can be investigated using multivariate analysis. The aim of the present study was to apply a comprehensive test battery to young players with a view to distinguishing between elite and sub-elite groups on the basis of performance on test items. Thirty-one (16 elite, 15 sub-elite) young players matched for chronological age (15–16 years) and body size were studied. Test items included anthropometric ($n = 15$), physiological ($n = 8$), psychological ($n = 3$) and soccer-specific skills ($n = 2$) tests. Variables were split into separate groups according to somatotype, body composition, body size, speed, endurance, performance measures, technical skill, anticipation, anxiety and task and ego orientation for purposes of univariate and multivariate analysis of variance and stepwise discriminant function analysis. The most discriminating of the measures were agility, sprint time, ego orientation and anticipation skill. The elite players were also significantly leaner, possessed more aerobic power (9.0 ± 1.7 *vs* 55.5 ± 3.8 ml·kg^{-1}·min^{-1}) and were more tolerant of fatigue ($P < 0.05$). They were also better at dribbling the ball, but not shooting. We conclude that the test battery used may be useful in establishing baseline reference data for young players being selected onto specialized development programmes.

Keywords: anthropometry, physiology, psychology, technical skill.

Introduction

The identification of talent in soccer is followed by selection onto a systematic programme for developing playing abilities and nurturing the individual towards realizing potential already predicted. Identifying talent for field games at an early age is far from being a mechanistic process. It is more complex in team games than in individual sports (e.g. track and field, swimming, rowing and cycling) where there are discrete objective measures of performance. Furthermore, later success in soccer is ultimately dependent on a host of external factors, including opportunities to practise, remaining free of injury, the nature of mentorship and coaching provided during development years and, finally, personal, social and cultural factors.

It is hardly surprising, therefore, that there are few, if any, models of talent identification that are at present globally accepted. Many of the proposed models are at best descriptive and schematic and there have been no real attempts to assess their validity. In the present study, a multivariate approach to the problem of talent identification is adopted. Multivariate analysis has previously been used with success in discriminating first-team professional soccer players from those remaining in the reserve team, the test battery including anthropometric, physiological and psychological measures (Reilly and Thomas, 1977). The merits of an interdisciplinary input to the process of talent identification are explored by means of a research programme designed to discriminate between elite young players and age-matched counterparts deemed to be sub-elite.

Despite the difficulties in predicting long-term success in young players, talent identification programmes are currently burgeoning in professional soccer clubs and national associations on a worldwide basis. Such systems are organized with varying efficiency and largely unknown effectiveness. None is firmly grounded on any

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scientific rationale. It is important, therefore, to generate scientific observations that might complement intuitive judgements about young talent. The necessary knowledge base encompasses the requirements for playing at an elite standard and longitudinal personal profiles of successful prototypes.

Matsudo *et al.* (1987) described the pyramid model they used in Brazil that embraced six tiers of performance abilities. The standards of proficiency ranged from physical education classes at the base of the pyramid to international competitors at its apex. Their test battery incorporated anthropometric, physiological and performance profiles and was expressed as 'intended for inferring training and selective factors'. Its use in specific sports was limited, other than directing individuals at an early age to the sports to which they seemed biologically most suited.

A multivariate approach to identifying talent in team games was applied with success by Pienaar and colleagues (1998). They were concerned with Rugby Union players under 11 years of age in South Africa. The test battery used contained 21 anthropometric variables, eight variables associated with motor and physical abilities and six measures of games skills. These researchers isolated eight variables for predicting talent (defined as reaching regional standard of participation) with a 94% success rate. The authors acknowledged that the work was pioneering for Rugby Union in their country and required refinement for longer-term predictions. It is also probable that the results were specific to the sport in question, although the model provided a useful template for analysis in other sports. A similar approach to talent identification in team games was adopted by Deshaies *et al.* (1979), who tried to differentiate skilled and less skilled ice hockey players on the basis of six biophysical variables, four hockey-specific skills and four psychological variables. Regression modelling indicated that four variables successfully discriminated between skill groups: anaerobic power, skating speed, visual perception speed and motivation. The model explained 55% of the performance criterion variance, with the hockey skills alone accounting for 33% and the psychological and biophysical variables explaining 20% and 17% of the performance variance, respectively. These models provide templates for viewing talent development systems in an objective way. For applications to soccer, there is a need to establish some essential information about the requirements of playing at elite standard.

The physiological requirements for participation in elite professional soccer have been described elsewhere (Bangsbo, 1994; Reilly, Bangsbo and Franks, this issue), as have the physical and physiological demands of the contemporary game at international standard (Reilly, 1997). The consequences for physiological and performance testing have also been outlined (see Reilly, 1996). In adult players, this kind of database is important for gauging current fitness and targeting musculoskeletal strengths and weaknesses for training purposes. Relevant measures include aerobic power (endurance), anaerobic power (speed), muscle strength, flexibility, agility (ability to change direction quickly), body composition (percent body fat) and somatotype (body shape). Their relative importance in the talent identification process has not been quantified.

The conceptual scheme outlined elsewhere in this volume (see Williams and Reilly, this issue) separates potential psychological predictors of soccer talent into personality and perceptuo-cognitive skills. The former include self-confidence, anxiety-control, motivation and concentration; the latter include attention, anticipation, decision-making, game intelligence and creative thinking. It would appear logical, therefore, to include measurements of these variables in any investigation of talent identification in young players. Measures of motivational orientation (see Duda, 1989, 1993), competitive anxiety (see Jones and Swain, 1995) and anticipation skill (see Williams, this issue) have already been shown to discriminate elite from sub-elite performers.

Any identification of physical and mental attributes necessary for success in sports is likely to be limited in value unless complemented by information about proficiency in the skills of the game. For this reason, any multifactorial battery of tests for supporting the talent identification process should include assessment of essential soccer skills. Tests for passing, shooting, controlling and dribbling the ball have been identified by Reilly and Holmes (1983) as the principal components in assessment of skilled play.

The aims of the current programme of research, therefore, were (1) to design and apply a multivariate test battery for assessing talent in young soccer players and (2) to assess its ability to distinguish elite from sub-elite young players.

Methods

Thirty-one (16 elite and 15 sub-elite) young male soccer players were studied (mean age = 16.4 years). Elite players (mean age 16.4 years, range 16.2–16.6) were classed as those who were signed for a professional club and played international youth soccer. Sub-elite players (mean age 16.4 years, range 15.8–16.7) were classed as those who were not signed for a professional club but had played regularly for various local and school teams. Informed consent was obtained before data collection.

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All participants were tested during the 1998–99 English competitive soccer season. Measurements for each participant were undertaken according to four categories: anthropometric, physiological and psychological profiling and soccer-specific skill performance. The procedures in each category are described in turn.

Anthropometric profiling

Fifteen measurements were taken from each player. These included height (m), body mass (kg), seven skinfolds (mm), two diameters and four girth measurements. The seven skinfolds were biceps, triceps, subscapular, suprailiac, mid-thigh, proximal calf and medial calf. The two diameters were biepicondylar humerus and biepicondylar femur. The four circumferences were for maximum upper arm, maximum forearm, mid-thigh and maximum calf. Anthropometric measurements were obtained using portable measurement devices (Holtain). Calibrated precision weighing scales were used to measure body mass. A cursor placed on the participant's head was used to help measure height. Skinfold thickness was obtained using a Harpenden skinfold caliper (British Indicators Ltd, Luton). Skinfold measures were taken at seven sites; values at four sites – triceps, biceps, subscapular and suprailiac – were used for the calculation of percent body fat (Durnin and Womersley, 1974) according to the tables provided by the caliper's manufacturers. The various measurements were used to provide indicators of body size, body composition and somatotype, which was established using the method of Carter and Heath (1990).

Physiological profiling

Eight variables were recorded for each player. These included aerobic performance (estimated $\dot{V}O_{2max}$) and seven anaerobic performance indices: 5-, 15-, 25- and 30-m sprints (speed), 40-m sprint with turns (agility), repeated sprints (speed endurance) and standing vertical jump (power). The estimated $\dot{V}O_{2max}$ values were calculated using a 20-m progressive run test (Ramsbottom *et al.*, 1988); $\dot{V}O_{2max}$ was predicted using the age-related tables provided by Lèger *et al.* (1988). The participants completed three runs each on the following tests to indicate an average and best score: 5-, 15-, 25- and 30-m sprints and 40-m sprint with turns. The 40-m sprint with turns followed the procedure reported by Borrie and Bradburn (1998). The repeated sprints entailed seven successive 30-m sprints (with 20 s recovery in between) from which a fatigue score was calculated (see Bangsbo, 1994). All sprint times were recorded using electronic timing lights (Body Care, Birmingham). A jump-mat was used to measure standing vertical jump (Cranlea, Birmingham). Three trials were performed, from which the highest distance jumped was recorded for analysis.

Psychological profiling

All participants completed three psychological tests – two questionnaires and an anticipation test. The two questionnaires were sport-specific: the Task and Ego Orientation in Sport Questionnaire (TEOSQ) (Duda, 1989) and the modified trait-based version of Martens and colleagues' (1990) Competitive State Anxiety Inventory-2 (CSAI-2) (see Jones and Swain, 1995). The TEOSQ provided a measure of motivational orientation, while the CSAI-2 indicated players' predisposition towards anxiety. The anticipation test used a film-based temporal occlusion approach, whereby participants were required to respond verbally when presented with 'life-size' film clips occluded 120 ms before foot–ball impact (see Williams and Davids, 1998). Thirty different clips were presented, divided equally into blocks of 1 *vs* 1, 3 *vs* 3 and 11 *vs* 11 soccer simulations. After viewing each film sequence, the participants were required to anticipate the intended direction of an opponent's dribble (1 *vs* 1) or pass (3 *vs* 3, 11 *vs* 11).

Soccer-specific skills test

The participants performed two skill tests, a shooting test and a slalom dribble test developed by Reilly and Holmes (1983). For the shooting test, the ball was kicked from a distance of 8.23 m towards one of nine distinct targets in the goal. The maximum score from nine shots was 27 points. The slalom dribble test entailed negotiating a zig-zag path with the ball around a series of cones to an end line and back again to the start. The time to complete this manoeuvre was recorded; four trials in total were performed and the aggregate time was recorded as the player's score. Electronic timing lights (Body Care, Birmingham) were used to measure the time taken for the slalom dribble test. Further details of the procedures are described by Reilly and Holmes (1983).

Results

Measurements were categorized into seven groups for statistical analysis. These categories included somatotype (endomorphy, mesomorphy, ectomorphy), body composition (sum of seven skinfolds, estimated percent body fat), body size (mass and height), speed (5-, 15-,

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25- and 30-m sprints), endurance (speed endurance, mean score and fatigue index), technical skill (dribbling and shooting tests) and anticipation (1 *vs* 1, 3 *vs* 3 and 11 *vs* 11). Each of these data sets was analysed using separate multivariate analyses of variance (MANOVA) in which group (elite, sub-elite) was the between-participant variable. Follow-up discriminant analysis and univariate analysis of variance (ANOVA) were used where appropriate.

Those measures not included in this initial procedure were analysed using separate analyses of variance for independent samples. These measures included age, $\dot{V}O_{2max}$, agility and standing vertical jump. In keeping with the convention adopted in previous research using the TEOSQ and CSAI-2 inventories, each of the respective sub-scales was analysed independently using ANOVA. Finally, all 31 dependent variables were analysed together to determine which combination of measures best discriminated between the two skill groups. A stepwise discriminant function analysis was used in which group (elite, sub-elite) was the dependent variable. The level of significance on all tests was set at $P < 0.05$.

Somatotype

The MANOVA showed that there was a significant difference between the two groups of players when the three somatotype measures were combined (Wilks' lambda = 0.74, $F_{3,27} = 3.09$, $P < 0.05$). Univariate ANOVA revealed a significant main effect on the endomorphy scale only ($F_{1,29} = 7.34$, $P < 0.05$). Elite players possessed lower endomorphy ratings than their less elite counterparts (see Table 1).

Body composition

The MANOVA indicated a significant difference between groups (Wilks' lambda = 0.65, $F_{2,28} = 7.43$, $P < 0.05$). Follow-up discriminant analysis showed that the sum of seven skinfolds (standard coefficient = –2.08) more clearly distinguished between groups than did estimated percent body fat (standard coefficient = 1.30). Univariate analyses showed significant differences between groups in both sum of seven skinfolds ($F_{1,29} = 11.65$, $P < 0.01$) and percent body fat ($F_{1,29} = 5.91$, $P < 0.05$). The elite players were leaner than the sub-elite participants (see Table 1).

Body size

No significant differences were indicated using MANOVA (Wilks' lambda = 0.85. $F_{2,28} = 2.48$, $P > 0.05$). Univariate ANOVA showed there was a significant difference in height between the two groups of players ($F_{1,29} = 4.83$, $P < 0.05$), the sub-elite players being slightly taller than their elite counterparts (see Table 1).

Table 1. Anthropometric characteristics of elite and sub-elite soccer players (mean ± *s*)

	Elite	Sub-elite
Body size		
Mass (kg)	63.1 ± 1.1	66.4 ± 2.5
Height (m)	1.71 ± 0.05	1.75 ± 0.06
Body composition		
Sum of skinfolds (mm)	47.9 ± 9.7	63.1 ± 14.5
Body fat (%)	11.3 ± 2.1	13.9 ± 3.8
Somatotype		
Endomorphy	2.1 ± 0.5	2.9 ± 1.0
Mesomorphy	4.0 ± 0.9	3.8 ± 1.1
Ectomorphy	2.9 ± 0.9	3.1 ± 0.9

Table 2. Physiological characteristics of elite and sub-elite soccer players (mean ± *s*)

	Elite	Sub-elite
Speed		
5-m sprint (s)	1.04 ± 0.03	1.07 ± 0.06
15-m sprint (s)	2.44 ± 0.07	2.56 ± 0.12
25-m sprint (s)	3.67 ± 0.13	3.79 ± 0.17
30-m sprint (s)	4.31 ± 0.14	4.46 ± 0.21
Speed endurance		
$\dot{V}O_{2max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	59.0 ± 1.7	55.5 ± 3.8
Mean score (s)	6.42 ± 0.16	6.74 ± 0.29
Fatigue index (s)	0.25 ± 0.19	0.39 ± 0.37
Speed endurance (s)	6.24 ± 0.19	6.74 ± 0.31
Power (SVJ, cm)	55.80 ± 5.82	50.21 ± 7.58
Agility performance (s)	7.78 ± 0.18	9.53 ± 0.73

Abbreviation: SVJ = standing vertical jump.

Speed

The MANOVA showed a significant group difference on the sprint tests (Wilks' lambda = 0.56, $F_{4,26} = 5.09$, $P < 0.01$). Separate analyses of variance indicated significant differences over 15 m ($F_{1,29} = 11.05$, $P < 0.01$), 25 m ($F_{1,29} = 5.50$, $P < 0.05$) and 30 m ($F_{1,29} = 5.83$, $P < 0.05$). Follow-up discriminant analysis revealed that performance over the 15-m distance more clearly distinguished between groups (standard coefficient = –2.35). The results are presented in Table 2.

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Table 3. Performance scores on the dribbling and shooting skills tests for elite and sub-elite soccer players (mean ± *s*)

	Technical skills	
	Dribbling (s)	Shooting (points)
Elite	15.49 ± 0.50	16.06 ± 3.45
Sub-elite	18.34 ± 1.13	16.78 ± 2.96

Endurance

Significant between-group differences were indicated by means of MANOVA (Wilks' lambda = 0.26, $F_{3,25}$ = 23.27, $P < 0.01$). The elite players recorded better performances on both speed endurance ($F_{1,27}$ = 27.35, $P < 0.01$) and mean score components ($F_{1,27}$ = 59.09, $P < 0.01$). Discriminant analysis showed that the mean score measure (standard coefficient = –1.73) distinguished between groups better than did speed endurance (standard coefficient = 0.92).

Agility, maximal oxygen uptake, standing vertical jump and age

Significant between-group differences were indicated by separate analyses of variance for agility ($F_{1,29}$ = 90.95, $P < 0.01$), $\dot{V}O_{2max}$ ($F_{1,29}$ = 4.47, $P < 0.05$) and vertical jump or 'power' ($F_{1,29}$ = 6.26, $P < 0.05$). Compared to the sub-elite group, the elite players had higher aerobic power, were more agile and better jumpers (i.e. more 'powerful') (see Table 2). The two groups did not differ in age ($P > 0.05$).

Technical skill

The MANOVA showed significant differences between groups on the skill tests (Wilks' lambda = 0.27, $F_{2,28}$ = 37.89, $P < 0.01$). Separate analyses of variance showed a significant difference on the dribbling test only ($F_{1,29}$ = 74.60, $P < 0.01$). These results are shown in Table 3.

Anticipation

Elite players had better anticipatory performance than the sub-elite participants as indicated by MANOVA (Wilks' lambda = 0.44, $F_{3,27}$ = 11.20, $P < 0.01$). However, univariate analyses showed that significant differences emerged on the 1 *vs* 1 simulations only ($F_{1,29}$ = 35.45, $P < 0.01$). These findings are presented graphically in Fig. 1.

Task and ego orientation

The ANOVA showed a significant difference between groups in task orientation ($F_{1,29}$ = 6.26, $P < 0.05$). No differences were apparent in ego orientation ($P > 0.05$). The elite players were more task-oriented than the sub-elite participants (see Table 4).

Table 4. Psychological characteristics of elite and sub-elite soccer players (mean ± *s*)

	Elite	Sub-elite
Motivation		
Task orientation	32.80 ± 3.05	30.64 ± 2.46
Ego orientation	19.33 ± 7.90	20.50 ± 6.45
Anxiety intensity		
Cognitive	22.46 ± 4.91	20.85 ± 4.27
Somatic	11.86 ± 1.55	17.57 ± 4.95
Self-confidence	27.20 ± 6.54	23.28 ± 5.28
Anxiety direction		
Cognitive	9.00 ± 9.47	1.50 ± 7.05
Somatic	13.33 ± 9.27	3.28 ± 6.08
Self-confidence	18.93 ± 5.24	9.71 ± 8.42

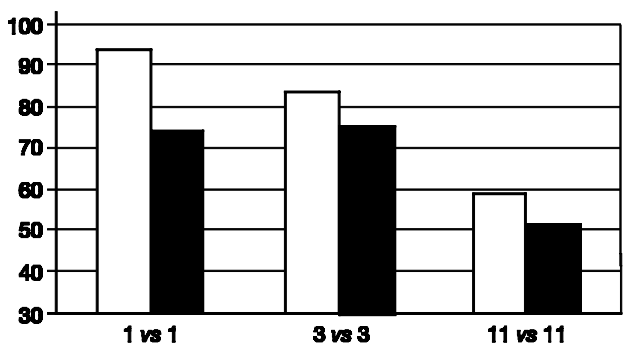

Fig. 1. Mean percent accuracy scores on the anticipation test for elite (□) and sub-elite (■) soccer players.

Anxiety

Significant differences between groups were indicated by means of ANOVA for somatic anxiety intensity ($F_{1,29}$ = 15.98), cognitive anxiety direction ($F_{1,29}$ = 15.98), somatic anxiety direction ($F_{1,29}$ = 10.03) and self-confidence direction ($F_{1,29}$ = 16.10, all $P < 0.01$). The self-confidence intensity scale also approached significance ($F_{1,29}$ = 4.00, $P = 0.05$). The elite players were less likely to experience somatic anxiety and were the more inclined to perceive cognitive and somatic anxiety as well as self-confidence as being facilitative to performance (see Table 4).

Stepwise discriminant function analysis

The results of the stepwise discriminant analysis are presented in Tables 5 and 6. The model predicted that a

Table 5. Summary of stepwise discriminant analysis: Variables entered/removed[a]

		Wilks' lambda							
							Exact *F*		
Step	Entered	Statistic	df1	df2	df3	Statistic	df1	df2	*P*-value
1	Agility	0.251	1	1	27	80.398	1	27	0.000
2	30-m sprint time	0.195	2	1	27	53.690	2	26	0.000
3	Ego orientation	0.155	3	1	27	45.262	3	25	0.000
4	Anticipation 1 *vs* 1	0.121	4	1	27	43.423	4	24	0.000

Note: At each step, the variable that minimizes the overall Wilks' lambda is entered.
[a] Maximum number of steps is 66; minimum partial *F* to enter is 3.84; maximum partial *F* to remove is 2.71; *F* level, tolerance or VIN insufficient for further computation.

Table 6. Summary of stepwise discriminant analysis: Variables in the analysis

Step		Tolerance	*F* to remove	Wilks' lambda
1	Agility	1.00	80.39	
2	Agility	0.53	88.15	0.86
	30-m sprint time	0.53	7.54	0.25
3	Agility	0.40	112.57	0.86
	30-m sprint time	0.41	12.88	0.24
	Ego orientation	0.74	6.34	0.20
4	Agility	0.40	58.72	0.42
	30-m sprint time	0.40	13.52	0.19
	Ego orientation	0.69	8.46	0.16
	Anticipation 1 *vs* 1	0.90	6.74	0.16

combination of four variables successfully discriminated the elite and sub-elite players. These measures were selected in the following order of importance: agility, sprint time over 30 m, ego orientation and anticipation skill on the 1 *vs* 1 simulations. The direction (signs) associated with the discriminant functions showed that performance on the agility test discriminated in a positive direction (+1.43), indicating that the faster performers contributed less to the elite centroid (–2.51) compared with the sub-elite group's centroid (+2.69). The positive coefficient reported for ego orientation (+0.66) and the negative coefficient for anticipation skill (–0.53) were predicted. Perceptual skill has been identified previously as an important characteristic of expertise (see Williams, this issue), while being too concerned with outcome rather than task mastery may have negative effects on performance and skill development over time (see Duda, 1989, 1993). The negative coefficient (–1.02) associated with the sprint times over 30 m was unexpected. Having identified the importance of speed over shorter distances expressed by the agility test, sprint performance over 30 m seems to provide no useful additional information when discriminating further between the two groups of players.

Discussion

Three anthropometric measures successfully discriminated between the two groups, namely sum of skinfolds, percent body fat and the endomorphy component of somatotype, according to the univariate analysis. Estimated percent body fat and endomorphy are both derived from skinfold assessments but the superiority of the sum of skinfolds to distinguish between the groups highlights the value of working with the complete array of raw measurements. The elite players were leaner and more muscular than their sub-elite counterparts. The goalkeeper profiles deviated from that of the other elite players, with skinfold measures similar to the sub-elite group. The anthropometric profile of goalkeepers should, therefore, be interpreted with caution in a context of talent identification.

For the purposes of this study, the groups were matched for chronological rather than maturational age. Matching the groups on the latter criterion was impractical. Nevertheless, a comparison of the mean values for height and body mass renders it highly unlikely that the groups differed on biological age. The small difference in body mass between the groups could be accounted for by the differences in body composition, while comparison of mean height would marginally favour the sub-elite rather than the elite group.

The physiological measures were generally more discriminating than anthropometry, with significant differences being observed on eight of the ten measures. The elite players recorded higher values for $\dot{V}O_{2max}$ and the standing vertical jump, and faster times over the 15-, 25- and 30-m sprint distances and the agility

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test than the sub-elite participants. The elite players also recorded better scores on two of the three speed endurance measures – mean score and fatigue index. The negative direction of the contribution of the 30-m sprint times towards the discriminant function equation was therefore surprising and is possibly a statistical artefact: sprinting speed is an important element in the agility run and performance in the two tests is generally highly correlated. Consequently, adding the 30-m distance to the agility run does not appear to contribute further to the identification of players in the elite group.

Elite players were faster than the sub-elite participants on the speed tests, although sprint time over 15 m was the strongest discriminator irrespective of playing position. The elite players were also better in reproducing top speed in the repetitive sprint tests and were more tolerant of fatigue. This ability to recover quickly from an all-out effort is an important component of fitness for soccer (see Reilly, Bangsbo and Franks, this issue). The ability to sustain high work-rates during competition is associated with high aerobic power ($\dot{V}O_{2max}$), another distinguishing feature of the elite group. The average value of 59 $ml \cdot kg^{-1} \cdot min^{-1}$ already approaches the levels observed in professional outfield players (see Reilly, 1996).

The elite players' better performance in sprinting was duplicated in higher values on the standing vertical jump test. Anaerobic power as well as aerobic power is important for success in soccer (see Reilly, Bangsbo and Franks, this issue). The results of the agility test emphasize that a better physiological make-up must be complemented by an ability to change direction quickly. This requirement is called upon repeatedly in match-play and in training. Indeed, agility was shown to be the most powerful discriminator between the two standards of proficiency. Raven *et al.* (1976) reported that an agility run test distinguished professional soccer players as a group from the normal population better than any field test used for strength, power and flexibility. They concluded that the agility of players was their greatest asset in setting them apart from normal individuals. The same conclusion can be extended to the elite young players in the present study.

Elite players were more task-oriented and less ego-oriented than sub-elite participants (see Table 3). Task-oriented players are more likely to participate in soccer for skill mastery and personal improvement and are interested in the game for its own sake. Ego-oriented players place greater emphasis on participating in soccer to increase self-esteem and social status by trying to be better than others. According to Duda (1993), a task or mastery orientation will lead to a stronger work ethic, persistence in the face of failure and optimal performance. Ego- or outcome-oriented individuals are likely to have low perceived competence and tend to perform less well in evaluative contexts. Elite players were also less likely to experience somatic anxiety and were more self-confident than their sub-elite counterparts. The elite players recorded higher scores on all three directional sub-scales. These higher scores suggest that elite players were more likely to perceive anxiety and self-confidence as being helpful rather than detrimental to performance. Jones and Swain (1995) reported similar findings with elite and sub-elite cricketers.

In general, the elite players performed significantly better than the sub-elite players on the anticipation test. The largest difference between groups emerged on the 1 *vs* 1 followed by the 11 *vs* 11 simulations. The ability to 'read the game' and to anticipate an opponent's intentions is an important characteristic of talented performers (for a more detailed discussion, see Williams and Davids, 1998; Williams, this issue).

The elite players performed better on the technical skill tests, although, as indicated in Table 4, only the dribbling test significantly discriminated between the two groups of players. Perhaps not surprisingly, only the forwards could be differentiated on the basis of the shooting test, whereas performance in dribbling was a characteristic of all the elite players regardless of playing position.

Multivariate statistical analysis techniques were used to determine which combination of the measures distinguished most clearly between the two groups of players. The analyses revealed that the groups could be discriminated on the basis of four measurements. The most discriminating measure was performance on the agility test followed by sprint times, ego orientation and the 1 *vs* 1 anticipation test. Speed, agility, motivational orientation and perceptual skill were the most important indicators of talent in soccer, although in the present study the isolation of the 30-m sprint test was an equivocal finding. The results from this analysis show reasonable agreement with those of Deshaies *et al.* (1979), who indicated that measures of anaerobic power, speed, perceptual skill and motivation successfully discriminated elite and sub-elite ice hockey players.

Conclusions and implications

The test battery designed for this investigation was multidisciplinary in the sense that it embraced anthropometric, physiological, psychological and performance measures. It therefore extended the work of previous research groups by tailoring the tests for application to young soccer players. The tests were administratively convenient in that the data were collected in 'field' conditions and did not require formal laboratory investigation. Moreover, the test battery proved to be of

practical significance in discriminating successfully between groups of elite and sub-elite players. The two groups were distinguishable on a range of individual measures, but the discrimination between them was optimized when the multivariate profiles were considered as a whole. Elite players have an advantage over their sub-elite counterparts in terms of body composition and shape, speed, speed endurance, vertical jumping, agility, motivational orientation, control and perception of anxiety, anticipation and technical skill. Of these measures, agility, speed, motivational orientation and anticipation skill appear to be the strongest predictors of talent. The next step would be to examine the validity of their use as predictors in a longitudinal study using a much larger sample. Such research would help to establish whether the proposed test battery is merely useful in talent discrimination rather than talent identification.

The present results demonstrate that elite players may be distinguished from sub-elite players on a comprehensive multivariate battery of test items. It remains to be seen whether these measures are able to discriminate among players already selected and exposed to systematized training. It may be suggested that the sensitivity of such tests tends to decrease once players reach the elite group. The measures included in the test battery are to a certain degree amenable to training or practice effects. Moreover, the predictive power of this battery does not necessarily apply to earlier or later age groups, as the relationship between test items may change with growth, development and training. The measures identified in this study may be more or less important in different age groups. A systematic programme of research is required to establish the validity and usefulness of such test batteries across varying age groups and standards of ability. Confirmation of test battery results with subjective player rating scales completed by scouts or coaches on a larger sample of players than was available for the present study would provide a more comprehensive perspective on the talent identification process. This type of approach holds much promise, combining an interdisciplinary scientific approach with the accumulated 'know-how' of soccer experts.

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