Improving talent identification and development in young distance runners

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ABSTRACT

Talent selection can be made by scientific methods or by coach selection. In many cases, coaches use a competition-ranking based method. Why selected athletes have performed in a certain way in the selection process or the 'pros and cons' of the choices made for their development are seldom considered. Many young athletes continue in an event despite the fact that they don't have the best characteristics for success in that discipline. Only after a dropout due to injuries or lack of motivation is it realised that mistakes might have been made in the decision to place an athlete in an event or event group. The main purpose of this study was to identify ways to reduce or eliminate health risks associated with athletic training by ensuring the best possible choice of athletic discipline. The authors also wanted to use testing and monitoring to learn more about the athletes' natural development, their training characteristics, their health and psychological status, and their future possibilities. The aim was to provide a conclusion as to what extent each athlete was suited for a particular athletic event and general recommendations for future work in the area of talent selection.

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Introduction

In talent development, the first step is the selection of talented young people. This can be made by scientific methods or by way of coach selection. In many cases, coaches identify athletes with potential for development through a competition-ranking based method. Why these athletes perform in a certain way or the ' pros and cons' of the choices made for their development are seldom considered. Many young athletes continue in an athletic discipline despite the fact that they don't have the best characteristics for success in that discipline. Only after a dropout due to injuries or lack of motivation do we realise that mistakes might have been made in the decision to place an athlete in an event or event group. In a 1999 pilot-study conducted by the Royal Dutch Athletics Federation (Koninklijke Nederlandse Atletiek Unie - KNAU) on a population of about 100 young athletes, it was found that in one year 75% of the subjects left the selection due to various reasons.[1]

In this study, conducted by the KNAU with the financial assistance of the European Athletics Support Programme, the main purpose was to identify ways to reduce or eliminate health risks associated with athletic training by ensuring the best possible choice of athletic discipline. We also wanted to use testing and monitoring to learn more about the athletes' natural development, their training characteristics, their health and psychological status, and their future possibilities. The aim was to provide a conclusion as to what extent each athlete was suited for a particular athletic event and general recommendations to the KNAU for future work in the area of talent selection.

Methods

Twenty-four young athletes (12 girls and 12 boys) were selected by a professional trainer to participate in the study. These athletes were chosen because they had positive ambitions but an uncertainty about their future athletic possibilities. They had competed already in several events and most were orientated towards middle- and long-distance events, but there was still no final decision made as to which discipline would be their best choice. The subjects had different training ages and levels of performance.

The intake procedure consisted of:

- Somatotyping and anthropometric assessment[2]
- Orthopaedic screening including an estimation of future height, joint function test and muscle length and function tests
- Resting EKG and a lung function test, including flow-volume loops in search of low grade asthma
- General medical examinations
- Blood analysis
- Psychological analysis

In the high performance laboratory, the O_2 kinetics were measured and also the anaerobic properties by way of the Wingate-Test. The parameters were:

- VO_2 max
- VO_2 max/kg
- VO_2 at the anaerobic threshold (V-method)
- Maximum heart rate
- Peak power/kg
- TTPP(Time to Peak Power)
- PFR (Power Fatigue Rate)

Also in the laboratory, vertical jump height and back extension strength were assessed as functions of muscle characteristics.

The blood analysis focused on:

- Haematology and white blood cells
- Vitamin B12 and iron status
- Metabolic parameters related to protein/carbohydrate balance (urea/creatine ratio)
- CK as a measurement of muscle strain due to training
- Hormonal profile testosterone/oestradiol and thyroid function
- Other energy intake parameters such as T3, IGF-I and prealbumin

For the psychological analysis, the athletes replied to three questionnaires by means of the internet. The three questionnaires were subjective instruments for a systematic and interactive evaluation of the athlete's psychological competences. The questionnaires used were:

- 'Psychological Achievement Inventory'[3], which measures eight sport skills necessary for optimal sport results
- 'Competition Orientation Inventory' (COI)[4], which gives insight into the ability to cope with negative thoughts, the ability to use images and the way the athlete handles competitions (goal oriented or competition oriented)
- 'Dutch Inventory of Eating Behaviour'[5], which measures how the individual handles food intake

During the season we registered the competition results. Unfortunately not all athletes could participate in all the tests due to several reasons (minor injuries, school, competitions).

Table 1: Anthropometric data

	Girls Average	SD	Boys Average	SD
Age (years)	16.1	1.2	16.4	1.2
Height (cm)	169.3	6.4	182.3	4.2
Weight (kg)	53.4	4.9	63.8	5.4
BMI	18.8	1.0	19.1	1.4
Body fat (%)	21.1	3.4	8.7	2.4
Bone weight (kg)	8.9	0.8	11.8	0.7

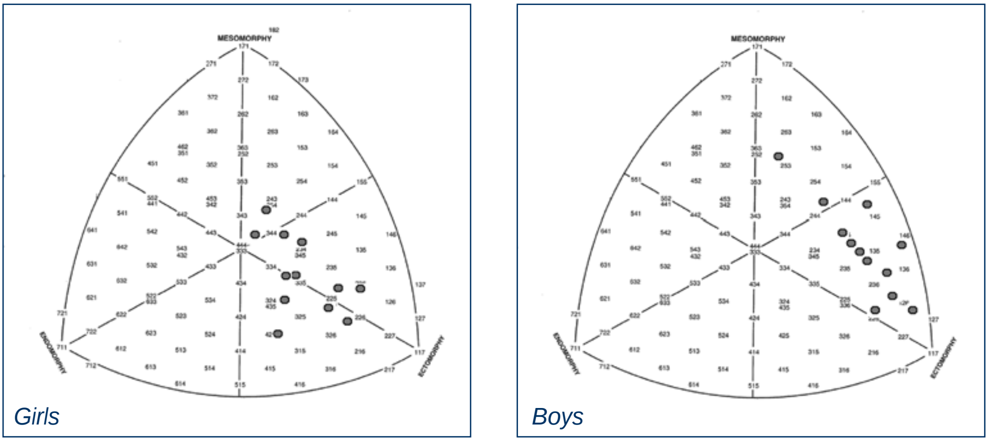


Figure 1: Somatocharts

Results

Somatotyping and anthropometric assessment

Somatotyping or kinanthropometry is also known as the interface between anatomy and movement. It represents the physique best fit for a certain task. The more an athlete differs from this ideal build the harder it is to reach the top.

The results of the somatotyping in our group showed that there was a tendency for central to ectomorph body build. The girls were somewhat more ectomorph and the boys were more ecto-mesomorph (Figure1).

The ectomorph type was indeed more correlated with a lower percentage of body fat and a lower body mass index. Though this is a small sample size, there was a significant ($p< 0.05$) correlation between the ectomorph somatotype and VO_2max, maximal running speed and the anaerobic threshold in the boys (but not in the girls).

The averages of the anthropometric data are given in Table 1. All the data are within the range for good middle- and long-distance athletes.

Physical examination

There were no gross abnormalities revealed in the internal exam. The orthopaedic exam surprisingly revealed a minor number of chronic injuries. Remarkable among these were stiff lower backs in the both the boys and the girls. Also, the average muscle flexibility was poor in both groups (Table 2). A score of ‘0’ reflects good flexibility, a negative

Table 2: Flexibility measured according to Waddell[6] and muscle flexibility according to Kendall et al[7]

	Girls	Boys	Ref Girls	Ref Boys
Flexibility lower back (cm)	22.0	21.7	22.5	22.5
Average muscle flexibility*	-2	-4	-1	-3

(0=normal muscle length, a positive value is above average, a negative value is under average muscle length.)*

score of more then '2' reflects a poor flexibility. A reference value from a sample of 500 sports students of the same age has been added to the table.

Cardio-pulmonary profile

There were no abnormalities in the blood pressure measurement or the resting EKG. In the lung function tests, only two athletes had an asthmatic flow volume curve, which was already known.

Laboratory profile

Some of the most relevant parameters are mentioned here. Haemoglobin (important for oxygen delivery), the hematocrit (the proportion of blood volume that is occupied by red blood cells) were measured and also serumferritine as an iron storage factor. Haptoglobulin is an indicator of red blood cell damage due to haemolysis for example by running on hard surfaces. CK is an indicator of muscle cell damage due to hard training and UKR (urea/creatine-ratio) is an indicator of protein breakdown due to intensive training and possibly insufficient glycogen intake.

Other diet related parameters are prealbumin, an indicator of energy intake, and T3, the thyroid hormone. TSH is an indicator of overall thyroid function. IGF I is a factor related to energy intake and anabolic state. Due to the young population these last values, were on average, very high. The results are shown in Table 3.

There were no cases of anaemia, but there were certainly low ferritin values in both boys and girls. In a few cases low haptoglobulin levels, high CK levels and low UKR levels were a reason for entering a conversation with the athlete and his/her coach about the training regime and running surface. The athletes and coaches were also give advice on diet and vitamin supplementation.

Table 3: Average values and standard deviations (sd) laboratory results

	Boys	sd	Normal Values	Girls	sd	Normal Values
Hemoglobulin (mmol/l)	9.7	0.6	8.5-11.0	8.8	0.4	7.5-9.7
Hematocrit (l/l)	0.50	0.03	0.40-0.50	0.40	0.02	0.38-0.50
Serumferritin (ug/l)	32.0	15.2	25-230	26.3	14.5	20-100
Haptoglobulin (g/l)	0.5	0.2	0.30-2.00	0.6	0.3	0.27-2.00
Creatinphosfatase (U/l)	225	126	<175	171	87	<160
urea/creatin-ratio	54.6	11.4	<80	59.5	11.3	<80
thyroid stimulating hormone (mIU/l)	1.7	0.6	0.4-4.3	1.5	0.7	0.2-3.5
Prealbumin (g/l)	0.26	0.03	0.20-0.40	0.27	0.05	0.20-0.45
Triiodothyronine (nmol/l)	1.8	0.4	1.1-3.1	1.8	0.4	1.5-3.0
Insulin-like growth factor I (nmol/l)	87	26	10-50	97	25	10-50

Table 4: Oxygen uptake parameters (VO_2max= maximal oxygen uptake, VO_2AT= oxygen uptake at the anaerobic threshold, $VO_2\%mx$=oxygen uptake at AT as percentage of maximal oxygen uptake, AT=anaerobic threshold, Vmax= maximal running speed on the treadmill, AT%mx= speed at AT as a percentage of maximal running speed.)

Girls					
VO_2max	VO_2AT	$VO_2\%mx$	AT	Vmax	AT%mx
64.30	60.40	93.9	15.20	19.30	78.76
62.20	56.60	91.0	17.00	20.00	85.00
52.60	46.20	87.8	15.00	19.00	78.95
57.50	53.90	93.7	14.70	19.00	77.37
57.80	54.30	93.9	16.00	20.00	80.00
56.20	50.80	90.4	14.50	19.00	76.32
62.90	55.10	87.6	17.30	20.00	86.50
54.00	50.60	93.7	16.30	19.00	85.79
64.90	57.70	88.9	15.30	19.50	78.46
61.60	56.90	92.4	17.00	20.00	85.00
66.30	54.90	82.8	14.40	18.00	80.00
63.70	56.30	88.4	17.00	20.00	85.00

Boys					
VO_2max	VO_2AT	$VO_2\%mx$	AT	Vmax	AT%mx
63.40	57.80	91.2	16.80	21.00	80.00
63.10	55.30	87.6	17.30	21.00	82.38
68.40	59.60	87.1	17.00	21.70	78.34
68.70	59.50	86.6	18.30	22.00	83.18
65.90	58.70	89.1	16.30	20.20	80.69
68.20	61.10	89.6	16.50	20.00	82.50
79.60	68.80	86.4	20.00	22.50	88.89
60.90	55.50	91.1	17.90	22.50	79.56
81.60	57.00	69.9	19.70	23.00	85.65
64.50	50.70	78.6	16.80	21.70	77.42
69.90	61.30	87.7	19.00	23.00	82.61
72.10	62.60	86.8	18.10	22.00	82.27

Aerobic profile

For middle- and long-distance athletes, aerobic characteristics are of the utmost importance. Middle-distance athletes generally have even higher maximal oxygen uptake levels than longer distance runners. The latter can profit from learning to run at a high percentage of their maximal oxygen uptake for a longer time. It is known that the maximal oxygen uptake has a high genetic component and that only 10-15% can be increased due to training. Therefore, a high maximal oxygen uptake is important in the selection of this group of athletes (Table 4).

If a maximal oxygen uptake of 75 ml/min/kg for elite men athletes and 70 ml/min/kg for

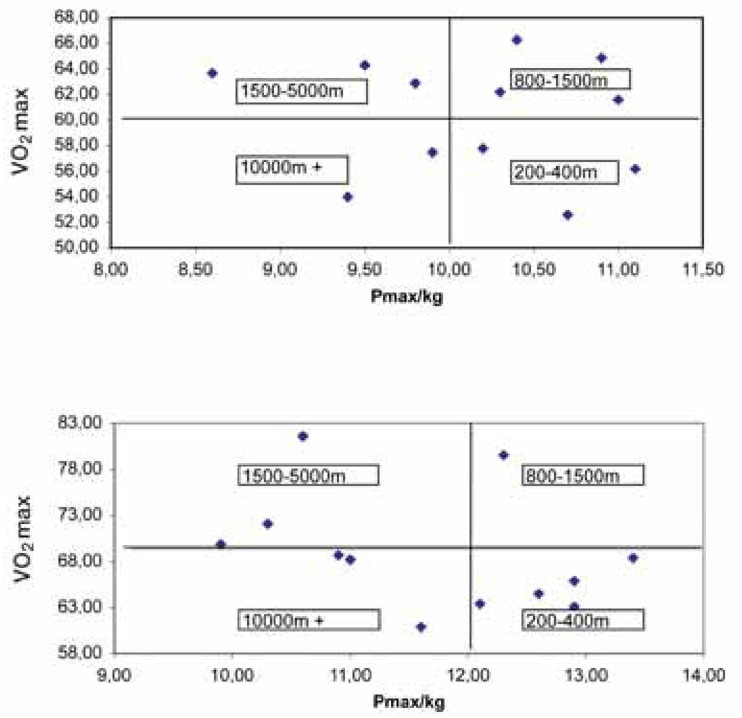


Figure 2: Maximal oxygen uptake and velocity at AT as a percentage of their maximal values (boys upper graph, girls lower graph)

elite woman athletes is a prerequisite[8] then talented young boys should have at least 69 ml/min/kg and girls at least 60 ml/min/kg oxygen uptake.

In addition to having a high oxygen uptake, it is important for distance runners to be able to run at a high velocity without having to use the anaerobic metabolism, measured by a high oxygen uptake at the anaerobic threshold (AT). But even with a high oxygen uptake at AT it is important that the muscles that use that oxygen generate a high running speed. That is to say, you have to be economic in your running style. And this economy is generated by the muscle characteristics. So muscle is the key factor to excellent running results.

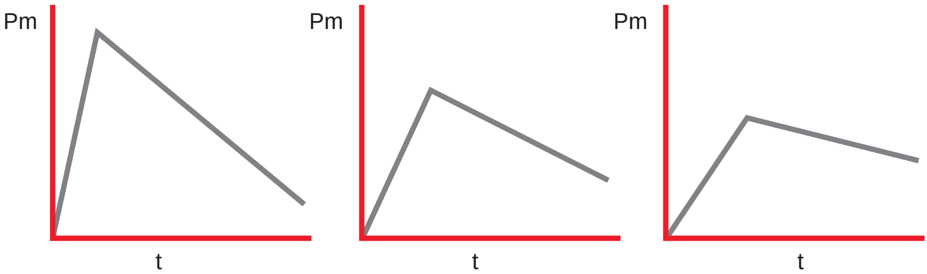
It is known that top athletes run at more then 85% of maximal oxygen uptake at AT and if they are economic they can run at that point at about 85% of their maximal running velocity. Young athletes will not be so far in their development that they reach these percentages, but it is interesting to see where they are scattered in the graph if we plot the running speed at the AT against the percentage of maximal oxygen uptake at the AT (Figure 2). The fact that you can run at a high percentage of your maximal oxygen uptake at the AT means that your mitochondrial volume is high and your metabolic system has a high aerobic energy yield. Running at a high velocity at the AT means that your body is able to generate this speed by means of a good mechanical muscular skeletal system. The graph gives us an idea how these features are developed in the group of athletes studied.

There are only a few athletes who meet both these requirements. So they are probably suited for more longer racing distances due to their greater economy, the key factor in these events.

In our results one notices that we are dealing with young athletes because when they score a high maximal oxygen uptake they were not always able to run at a high oxygen uptake as a percentage of the AT. More over they also were not able to generate a high running speed at this point. They clearly have to develop these features.

Table 5: Wingate-Test results

Girls PP/TTPP Watt/s	Pmax/kg Watt	PFR Watt/s	Lamx Mmol/l	Boys PP/TTPP Watt/s	Pmax/kg Watt	PFR Watt/s	Lamx Mmol/l
45.00	9.50	3.80	15.20	87.90	12.10	12.10	15.00
53.40	10.30	2.70	11.70	111.80	12.90	14.60	16.60
50.70	10.70	9.80	15.40	69.20	13.40	14.80	9.10
42.40	9.90	6.50	16.50	56.20	10.90	9.10	15.00
53.10	10.20	7.30	17.40	75.10	12.90	12.70	15.20
46.70	11.10	8.10	18.30	65.70	11.00	8.40	17.80
42.90	9.80	4.10	12.20	63.70	12.30	10.40	15.00
48.60	9.40	6.70	13.40	77.90	11.60	11.20	14.80
33.10	10.90	7.20	16.00	67.90	10.60	7.60	13.20
56.90	11.00	7.80	15.10	82.90	12.60	11.30	16.00
70.70	10.40	8.50	12.80	59.10	9.90	4.60	11.00
43.10	8.60	4.00	11.20	49.70	10.30	4.70	8.00



Type: Short-Distance	Type: Middle-Distance	Type: Long-Distance
TTPP: short	TTPP: short	TTPP: long
PP/TTPP: high	PP/TTPP: moderate	PP/TTPP: low
PP: high	PP: high	PP: low
PFR: high	PFR: moderate	PFR: low
Lamx : high	Lamx: high	Lamx: low
AUC: large	AUC: large	AUC: small
100-400m	800-5000m	5000m+

Figure 3: Characteristics of the Wingate curve for potential sprinters, middle- and long-distance runners (AUC=area under the curve)

Table 6: Muscle test results

	Girls average	sd	reference	Boys average	sd	reference
SJ cm	37.0	3.1		44.0	5.7	
CMJ cm	40.3	3.8		46.6	5.9	
Back extension kg	84.1	10.6	85	129.4	20.3	135

Anaerobic profile

As we stated earlier, muscle is the key factor to success. We tested the anaerobic profile by means of the Wingate-Test on a bicycle, which gives us, in combination with lactate values, an indication of muscle type (Table 5). The anaerobic power also has a strong hereditary component but as measured by the Wingate-Test it is not so dependent on training status and training age as, for example, the maximal oxygen uptake during running.

In elite 800m runners we measured peak powers of 12.5 to 13.0 Watt/kg and these values are also reached by some of the youngsters studied. High lactate values support the possibility of having a predominance of Type II 'fast' muscle fibres. High lactate and low power output is possibly due to a poor training and fitness status.

Athletes with strong explosive muscles type are able to reach a high power output in a short time; they have a short Time To Peak Power

Table 7: Average values for selected physical characteristics by event (X and Y are the coefficients for somatotyping plots, BMI ='body mass index', VO_2%mx=oxygen uptake at AT as a percentage maximal oxygen uptake, AT=anaerobic threshold, Vmax= maximal running speed on the treadmill, AT%mx= speed at AT as a percentage of maximal running speed.)

	Boys 200-400	800-1500	1500-5000	10,000+
X	2.98	5.13	4.29	3.51
Y	1.29	-3.21	-0.95	-0.16
BMI	20.1	17.4	18.2	19.2
Fat (%)	9.4	6.2	6.6	10.4
bone weight (kg)	12.1	11.4	11.3	11.9
back muscle strength (kg))	146.5	99.0	124.0	120.3
VO_2 %mx	86.7	86.4	81.5	89.1
AT%mx	79.7	88.9	83.5	81.7
AT (km/h)	16.8	20.0	18.9	17.6
Vmax (km/h)	21.1	22.5	22.7	21.5
400m (s)	51.2			51.5
800m (s)	116.7	116.0	119.0	118.0
1500m (s)	260.0	250.0	243.0	242.0
SJ (cm)	40.1	31.4	28.6	33.1
CMJ (cm)	42.9	34.0	30.5	35.5
30m sprint (s)	4.21	4.48	4.58	4.34
30m 'flying start' (s)	3.29	3.43	3.59	3.41

(TTPP), a high PP/TTPP and a high maximal peak power related to body weight (PP/kg). Due to their explosive muscle characteristics, they are not able to sustain this power output long, so they have a high power fatigue rate (PFR) or bad resistance to the acidification of their muscles. Their maximal lactate is therefore high after the test. These athletes are more suited for the 200m and 400m.

Athletes with more slow muscle type characteristics have a long TTPP and a low maximal power. Their PFR is usually high because they generate less acidity in their muscles and are therefore better suited for longer distances (10,000m and longer). Middle-distance runners (1500-5000m) display curves that are between the two mentioned above (Figure 3).

Athletes who showed in their aerobic profile a tendency towards long-distance had indeed on the average lower power output and lower lactate values after the test, which corresponded to the specific Wingate-profile of low power output and better PFR values.

Girls 200-400	800-1500	1500-5000	10,000+
1.42	2.82	0.94	2.39
-0.06	-2.20	-1.83	-1.38
18.9	18.4	19.1	18.9
20.8	19.6	24.4	20.1
9.0	9.3	8.3	9.4
93.7	84.5	76.0	78.0
90.7	88.8	90.0	93.7
78.4	82.1	83.4	81.6
15.2	15.9	16.5	15.5
19.3	19.4	19.8	19.0
57.3	59.0	56.0	60.0
135.7	134.2	132.0	140.0
295.0	285.0	273.5	288.0
32.7	34.6	29.4	27.6
34.6	37.0	30.0	28.4
4.55	4.57	4.56	4.92
3.67	3.64	3.78	4.14

There is no strong correlation in this young group between lactate and maximal power output. This is probably because the athletes were not yet well trained for resistance to fatigue or lactate tolerance.

Muscle tests

The results of the standing jumping height (SJ) and countermovement jumping height (CMJ) and back extension, strength are summarised in Table 6. As a reference for the back extension the average of the values for 500 sports students of the same age is added. The average back extension of the boys is somewhat below the reference, indeed the somatotype (more ectomorph) may be contribute to this.

Interaction between profiles

Aerobic and anaerobic profile

Theoretically a high maximal oxygen uptake and a high anaerobic power should make one the ideal athlete for middle-distances. Unfortunately in nature this is not often the case, though there are athletes who come close.

Therefore, we plotted the VO_2max against the Pmax in a square graph (Figure 4) and made a division by way of cut-off points. By doing so we created four groups of athletes suited for different distances. Though the number of athletes in every square is very small we summarised their average values in Table 7. This gives an idea of the characteristics by making such a division based on aerobic and anaerobic profiles.

Because maximal oxygen uptake, maximal power output and maximal lactate are not correlated in our data, and so are probably independent variables, we used these variables to make a flow chart for athlete classification (Figure 5). The cut-off points we used in the square graph and the flow-chart were the average values of the variables.

As stated earlier, in the Wingate-Test the youngsters reach values comparable with

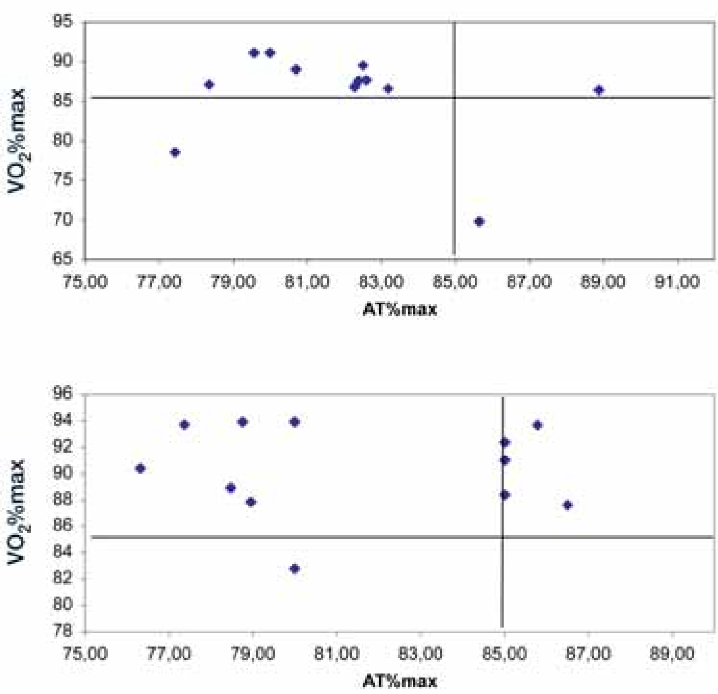


Figure 4: Square graphs of VO_2max and Pmax of boys (upper graph) and girls (lower graph)

Table 8: Competition result of the athletes during the research project

Distance	Girls Minimum	Maximum	Average	Boys Minimum	Maximum	Average
400m	55	64	58.4	48	56	51.2
800m	2.07	2.20	2.15	1.53	2.04	1.57
1500m	4.23	4.55	4.43	3.57	4.24	4.09

that of elite athletes, but this is not the case in the values of the oxygen uptake. It seems that the oxygen uptake, though having a strong genetic component, is more dependent on training status and is not yet well developed in all of these athletes. Especially the percentage of the VO_2max at AT is a strong predictor of running performance. The same counts for the economy of running, which is reflected by the running speed at AT. This component is highly influenced by muscle characteristics. It is the variation in trainings years and training status that makes it difficult to analyse the data with the purpose to predict their future abilities. This variation is reflected in the competition results (Table 8).

To summarise, the square graph in Figure 4 reflects the athletes fit for a certain distance. The graph in Figure 2 gives an idea which characteristics the athletes have to develop, i.e. metabolism or muscle, to get better.

Table 9: Average scores of (PLLS) sport skills

Mental sport skills	Boys	Girls
Self-confidence	4.05	3.98
Control over negative energy	3.97	3.55
Concentration	4.25	4.06
Mental representation	3.38	3.36
Positive energy	4.17	4.04
Motivation	4.23	4.22
Sport attitude	3.61	3.54
Perseverance	3.43	3.81

Table 10: Purpose-orientations in athletes (COI)

Orientation	Boys	Girls
High task-orientated	10	9
High competition/ego-orientated	2	
Mixed task/competition-orientated	3	

Table 11: Eating behaviour in athletes (NVE)

Eating behaviour	Boys	Girls
Lose Weight	6	3
Emotional Eating	6	3
External Eating	9	2

Muscle tests

We stated earlier that a high oxygen uptake at AT and high running speed at AT may predict success in middle- and long-distance running. If we look however at the muscle characteristics, reflected by the test protocol, there was no correlation between the Wingate-Test results, the jumping and back extension tests and the running speed at AT as a percentage of the maximal running speed. This feature maybe needs more emphasis in young athletes by training their muscles in order to gain more speed with the same amount of oxygen use. Indeed it is shown in the literature that running results improve when plyometric training is introducing.[9,10]

The high jump tests showed a strong correlation with the Wingate results so these test are useful for trainers to measure muscle characteristics at the track.

Psychological profile

The PPLS questionnaire gives some insight into mental skills necessary for optimal results in sports. A reference value for sports at a national level is four. The highest attainable level is five. In the group of young girls there was a low score on the items ‘control of negative energy’, ‘mental representation‘ and ‘sports attitude’. There were high scores on ‘concentration’, ‘positive energy’ and ’motivation’. The boys scored low on ‘mental representation’, ‘sports attitude’ and ‘persever-

Cut off points	Boys	Girls
VO_2max ml/min/kg	69	60
Pmax/kg Watt/kg	12	10
Lamx mmol/l	14	13

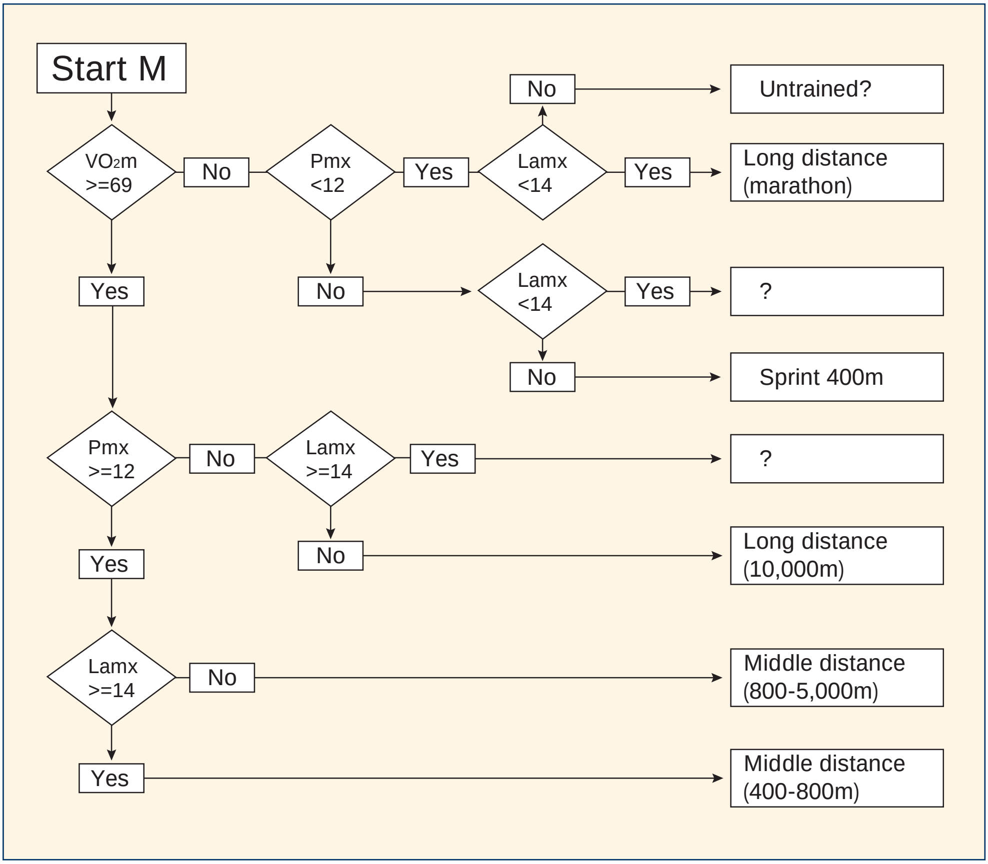


Figure 5: Flowchart for event selection in young male athletes (This is an example how one can try to make a fast and preliminary selection of large groups of young athletes by using the three physiological parameters. The cut off points can be chosen based on results of average value of young athletes or in the table on results of top athletes from their younger years.)

ance' and high on 'concentration', 'positive energy' and 'motivation'.

Female athletes (girls) with lower scores related to control of negative emotions will not perform optimally. The ability to control the negative emotions is a determinate factor in sport. The score for use of mental representations for preparation of sport movements and sport situations is not quite normal. Athletes have a high motivation level and training a source of positive power. The athletes with a weak will to win feel less challenged to perform well in important matches and lack the will to perform at the highest level. The score on perseverance is for boys was very low. The boys studied are less willing to sacrifice themselves for success than the girls.

The scores from the COI questionnaire showed that most of the athletes studied were 'Task-Oriented' and a few mixed 'Task- and Competition/Ego-Orientated'. The former are generally better for the development of skills and improvement of competences. The competition/ego-oriented athletes are focussed on success. They see their talents as a stable gift, which you either have or don't. Every athlete is task-oriented as well as competition/ego-orientated. The level of both orientations can be different between athletes.

Athletes with a dominated task-orientation will chose rather more difficult tasks and will easily get into trouble overloading themselves. Trainers of athletes with a high task-orientation should observe their athletes very carefully for overloading symptoms and try to curb their enthusiasm. Task-orientated athletes need more relay training for example to perform optimally.

Athletes with a high competition-orientation should choose easy matches because they need success to stay motivated. The lack of success is a reason to stop.

The 'Dutch Inventory on Eating Behaviour' measures three factors:

- Losing Weight is related to the inhibition of food with the aim to stay on weight or lose weight
- Emotional Eating relates eating to negative emotions
- External Eating is related to the perceptibility of food and strong food incentives like smell and taste

Nine of twelve athletes had problems to stay on weight. Most of them swing in their body weight lightly. None of the athletes indicate that their weight was a big problem. Trainers believe that body weight stability is an important factor for success in sport.

Conclusion

In the intake we discovered that a coach selected group had wide differences in potential and physical characteristics. There were not many health risks detected during the physical examinations, but there were many athletes who were at risk of getting chronic injuries due to imbalances and lack of muscle flexibility.

So it was important to help them to get on the route to their most suited distances but this was not easy.

With young athletes you are often unaware if the competition results at intake are due to talent or to a lot of early training. This was not always easy to analyse because they appeared to have a poor discipline in recording their training sessions.

Somatotyping was essential in the search for misfits between body build and athletic discipline. It is obvious that a high maximal oxygen uptake and muscular body build with a high bone mass is not a positive feature for middle- or long-distance running.

The laboratory results gave us insight into which athletes had to be careful about doing too much running on hard surfaces and keeping their energy balance right. Particular medical diseases were not found.

In this study we focussed on aerobic and anaerobic potential as key factors for success where the latter is determined by muscle characteristics, which are good to estimate even if an athlete has not trained for long.

Aerobic characteristics are thought to have a strong hereditary component whereas anaerobic threshold and running economy are much more influenced by the training regime.

Combining the aerobic and anaerobic profile in the cross graph in Figure 4 gave us insight into the athletes' future possibilities as measured by their present characteristics. Using oxygen uptake and running speed at AT, factors essential to middle- and especially long-distance running, the cross graph in Figure 2 was created. The graph gives us some idea which component has to be focussed on in the training sessions, i.e the metabolic component or the muscle component, in order for the athlete to improve his/her performance.

The psychological examination revealed that it is important that coaches learn to recognise some features of the athletes they train in order to get and keep them in mental balance. This was done during the research project by means of clinics. The coaches also learned which athletes had a high task-orientation because these athletes have to be observed carefully to avoid symptoms of overloading.

It was remarkable that it was the boys who presented the most features of emotional eating. These athletes are at risk of having some problems with their body weight and careful watching is necessary. Also a dietary inventory is advisable for this group.

The overall conclusion from the psychological point of view is that most of the athletes would benefit from regular mental training.

The results of this study were discussed with the head coach and the personal coaches of the athletes in order to help create a situation were the individual characteristics are better fit to future running distances.

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