FIFA
For the Good of the Game

8

Physical preparation and physical development and training

1. Physical condition and today's game: some facts and figures

The competition-related activity of today's footballers

- Between 60 and 70 matches per season for international players (for their club and national team, as well as friendly matches).
- Between 50 and 60 matches per season for international-level young players (aged between 16 and 20), with 10 months of competitive matches.
- Between 35 and 40 matches per season for young, talented players who are being groomed for the highest level.
- An increase in the amount of travel for both domestic competition matches and international matches.

Activity during a match

- **Matches are now longer than before:** An average match lasts between 93 and 98 minutes; the average amount of actual playing time during a match has increased from 50 to 55 minutes in 1990 to more than 60 minutes today.

- **Players can cover distances of between 10 and 13 km during a single match:**
  - Central defenders: 8 - 10 km
  - Defenders / outside midfielders: 9 - 12 km
  - Midfielders: 11 - 13 km
  - Attackers: 9 - 10 km

  → 5 to 6 km at slow running or walking pace (60 to 70% of MHR [maximum heart rate]
  → 2.5 to 3.5 km of moderate to high-speed running (80 to 90% of MHR)
  → 1.5 to 2.5 km of intense running at the player's anaerobic threshold (90 to 100% of MHR)
  → 600 to 1200 m of sprinting (50 to 70 sprints)
  → 300 to 400 m of backward running

- **150 to 200 individual actions**
  15 to 30 jumps
  30 to 50 duels
  between 15 and 30 seconds' recovery time between moments of intense action
  between 30 and 70 – or even more – ball contacts (depending on the player's position)

→ **Football is a sport requiring high-intensity, intermittent effort, hence the importance of aerobic/anaerobic endurance and explosive speed.**

Physical preparation has definitely been the one element that has developed most over the past two decades as far as training is concerned. This has been due to research, to experience gained in the field of physiology, to the support provided by sports medicine, to the recovery methods being practised, and to the quality of the training process as a whole.

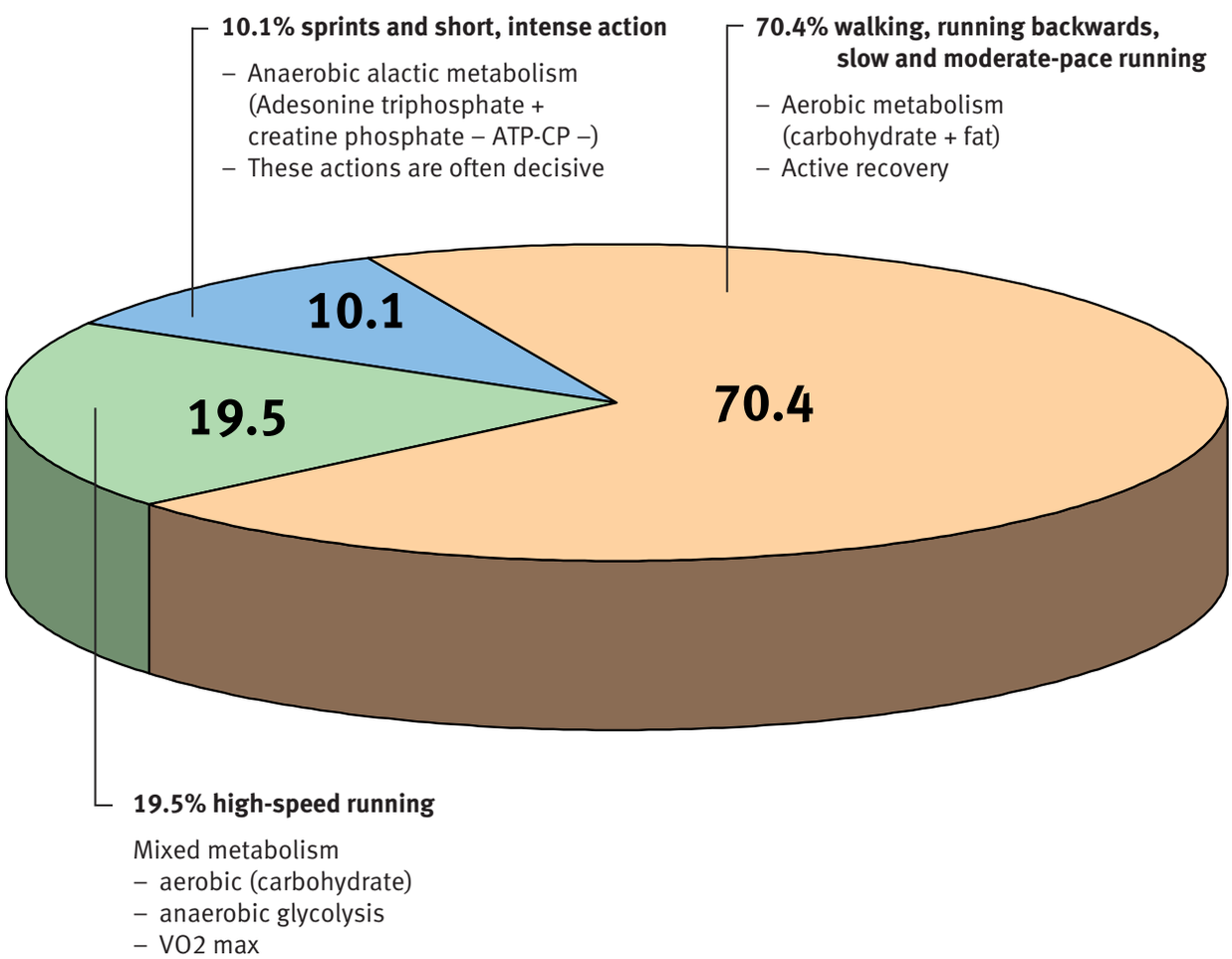
The aim of correct physical preparation in training is to enable the player to use his technical, tactical and mental capacities to the full and for as long as possible throughout the match and even throughout the season.

If young players are to go on and play top-level football, it has now become increasingly important that they have a solid athletic and mental foundation on which to build. This long-term athletic preparation starts at the age of 12–14, but in a gradual way that takes into account the players' growth, their personal rhythm of development and their performance potential.

When working on physical condition in training sessions today, the ball has to be used as much as possible, since it is the essential "tool" of any footballer. This applies as much to top-level professional players as it does to youth players.

Nevertheless, depending on the objectives of a given training session, we shall see that it is important to strike the correct balance between **integrated physical training (with the ball) and separate physical training (without the ball).**

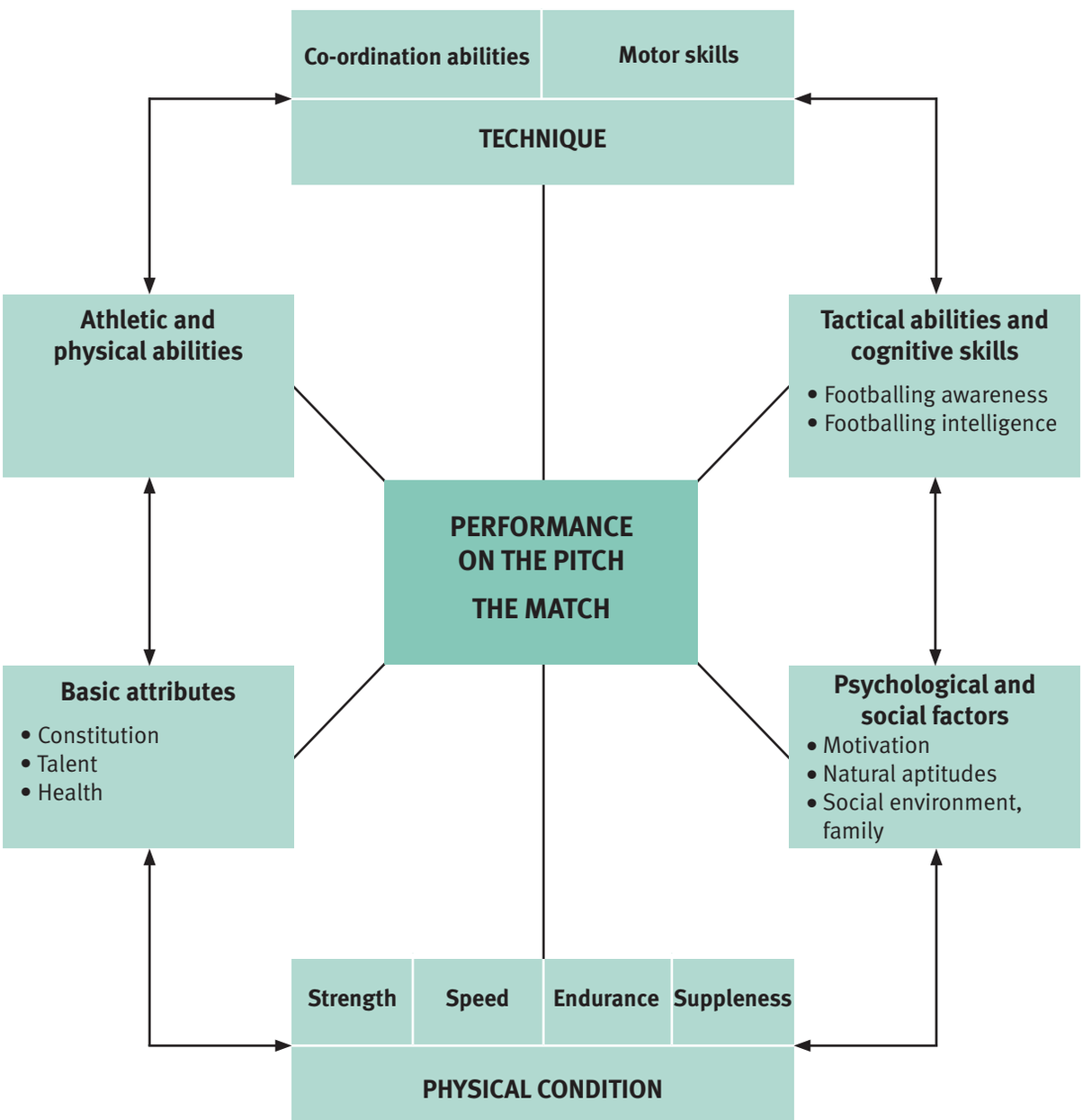
Table 1: Physical actions in the course of a match and the energy metabolisms used in each case (2002)



2. The performance capacities of the footballer

Performance during a match is conditioned by several elements.

Table 2: The elements that contribute to sporting performance
(Grosser et al. 1986)



A player's athletic and physical qualities are the building block for all other elements of his performance. The harmonious and methodical development of these elements will ensure that the football player is properly "constructed".

Table 3: The physical condition of the footballer – A golden triangle

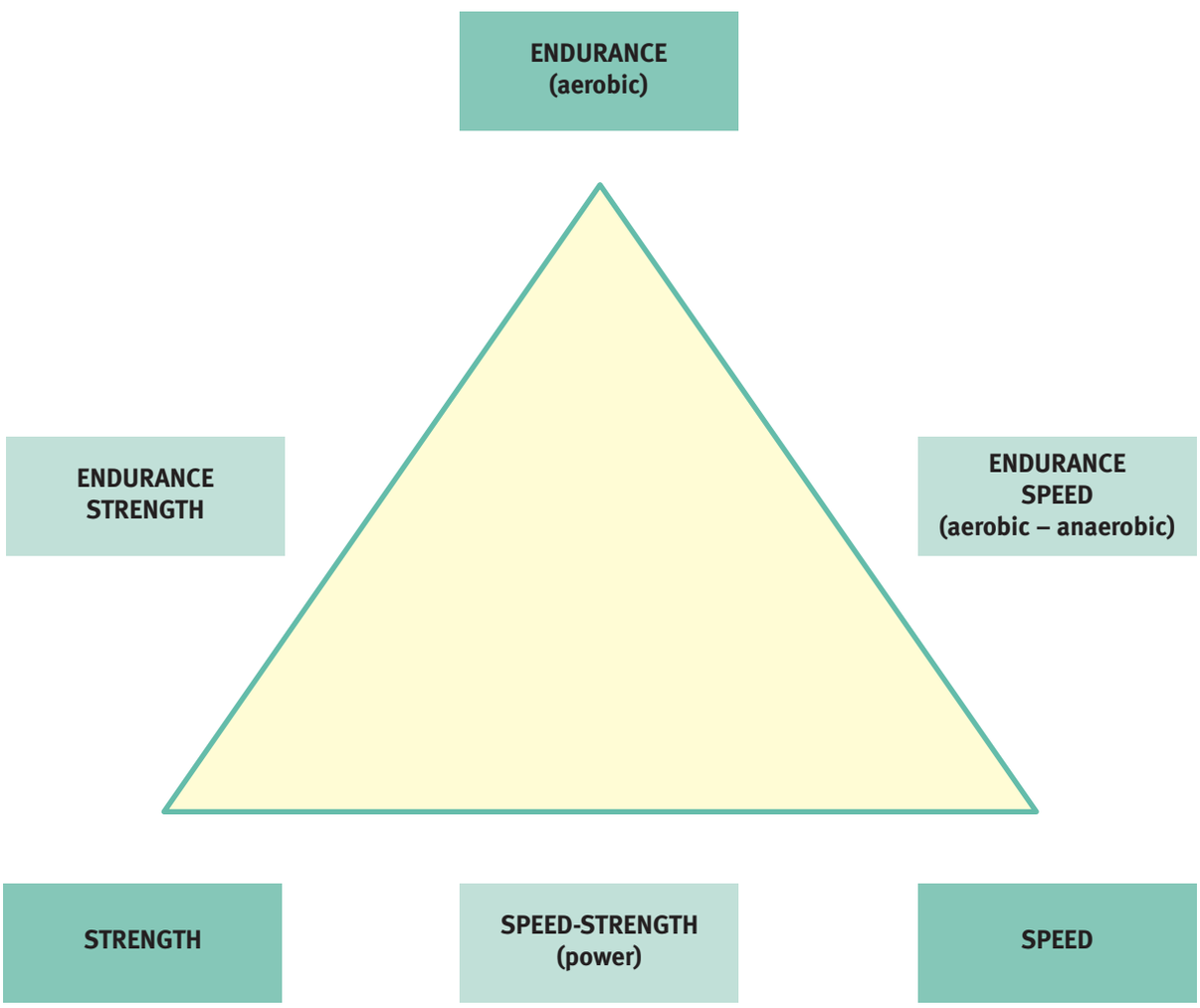
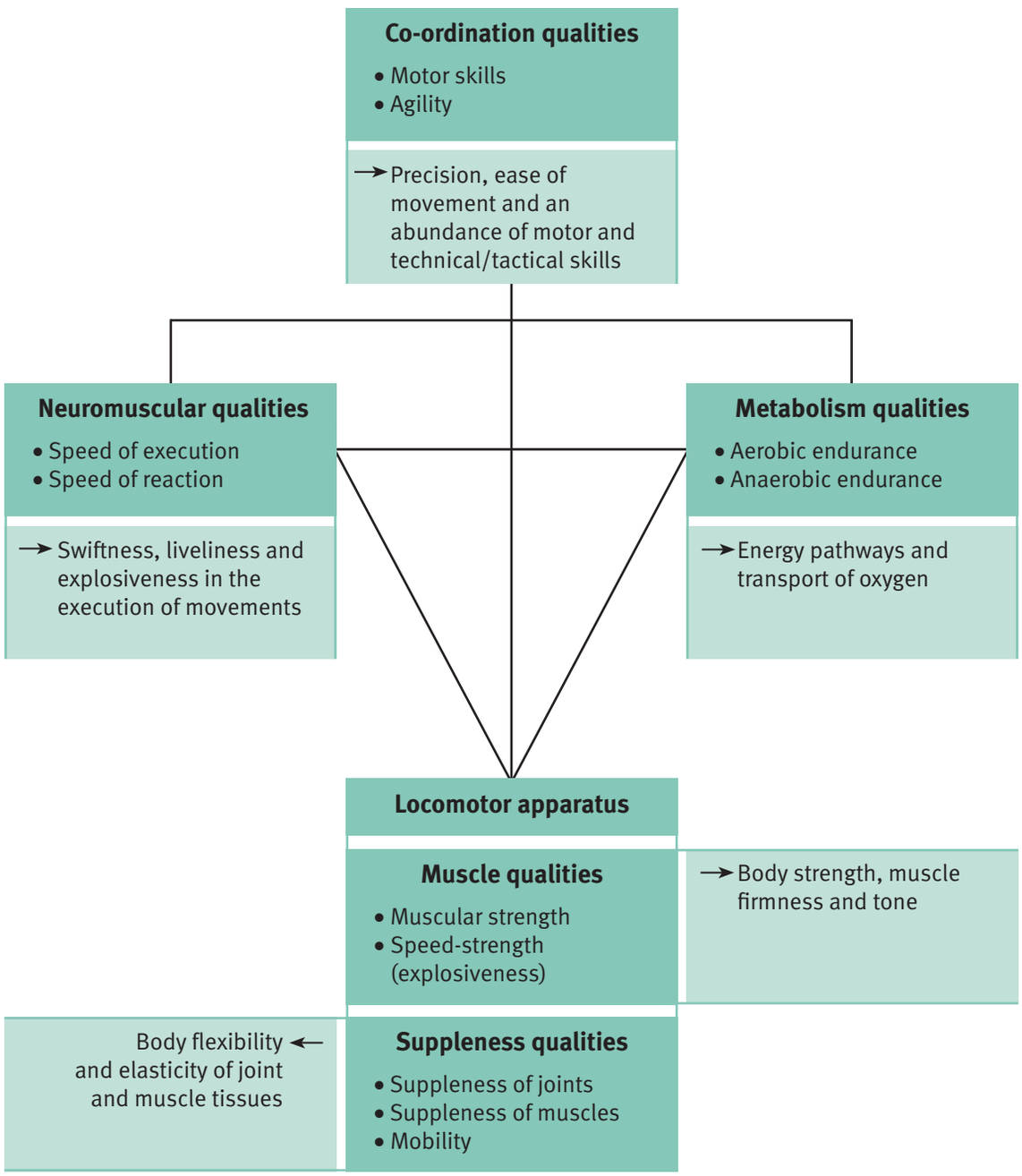


Table 4: Factors that determine the physical condition of the footballer



A solid locomotor apparatus and good organic and neuromuscular qualities are essential if a player is to possess high-precision co-ordination skills. Having a healthy, athletic and robust body helps to enhance these neuromuscular qualities and the player's psychomotor and technical skills.

Definitions

Co-ordination:	Co-ordination lies at the root of good technical proficiency. Co-ordination abilities allow the individual to control, regulate and master his movements with precision.
Speed:	This could be described as the "aristocratic" element of today's game. Speed is the factor that allows the individual to execute motor actions as swiftly as possible, as a result of the functioning of the processes of the neuromuscular system and the body's strength processes.
Muscular strength:	Muscular strength is the faculty that allows the individual to generate tension in a muscular contraction. It can be generated either by a muscle or a muscle group. This tension is generated in an explosive manner and gives rise to muscular power (a product of the strength that is generated by the speed of the movement). It goes hand in hand with physical vigour, tone and dynamism and boosts self-confidence.
Suppleness (mobility):	Suppleness is the ability to execute movements involving one or more joints with ease and with a great range of motion. Suppleness is dependent on two factors: articular mobility and the ability to stretch the muscle.
Aerobic endurance:	Aerobic endurance is the capacity of the body to tolerate bouts of effort for as long as possible, without this effort being interrupted. Sufficient quantities of oxygen (O_2) are required as "combustion" for this type of endurance. This factor helps the body to recover between bouts of effort.
Anaerobic endurance:	Anaerobic endurance is the capacity of the body to tolerate bouts of intense exertion without oxygen (O_2) consumption. With this type of very high-intensity endurance, the anaerobic process produces lactic acid; the muscle is then saturated with acid, which can often cause a reduction in the intensity of effort or even lead to the movement stopping altogether and with it the particular action in a match.

3. Endurance qualities (the aerobic and anaerobic energy pathways)

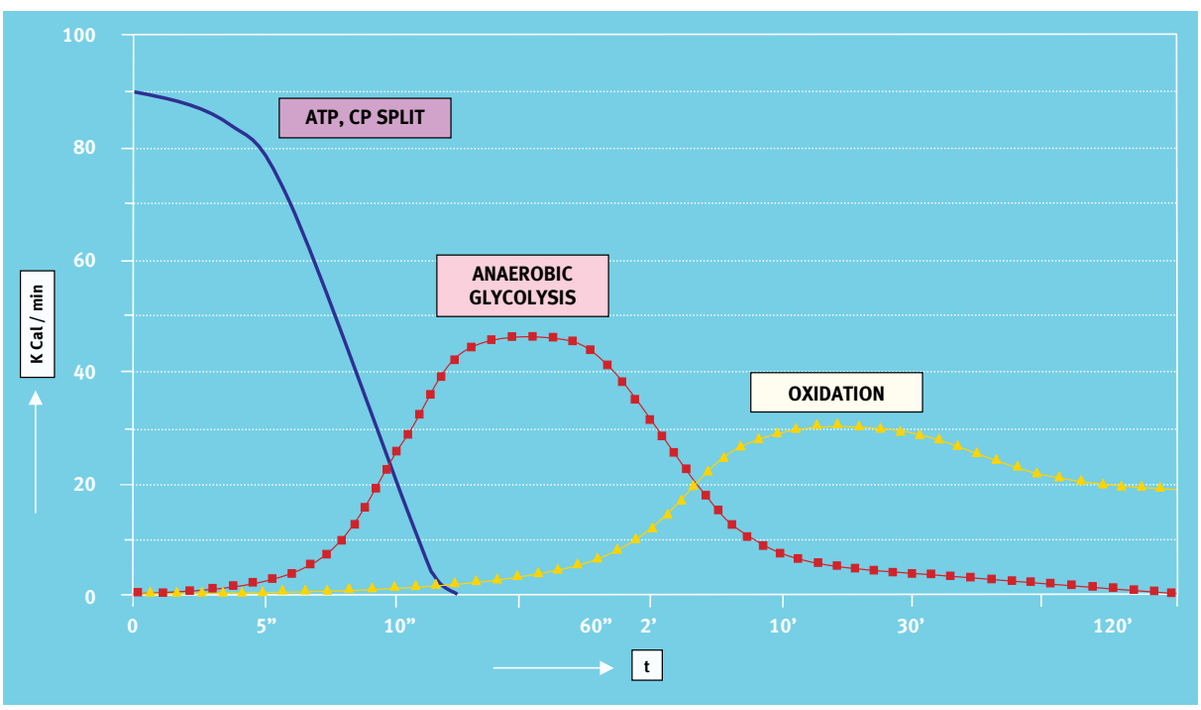
The muscles function thanks to the supply of energy substrate that comes from food energy sources and from a natural oxidant, namely oxygen (O_2), to produce the necessary fuel: **adenosine triphosphate (ATP).**

ATP is synthesised (produced) through the activity of three energy pathways:

- The ATP-CP pathway (rich in energy for explosive and short-term muscular contraction)
- The glycolytic pathway (degradation of the glucose carbohydrates)
- The oxidative pathway (the process of degradation of the substrates with oxygen)

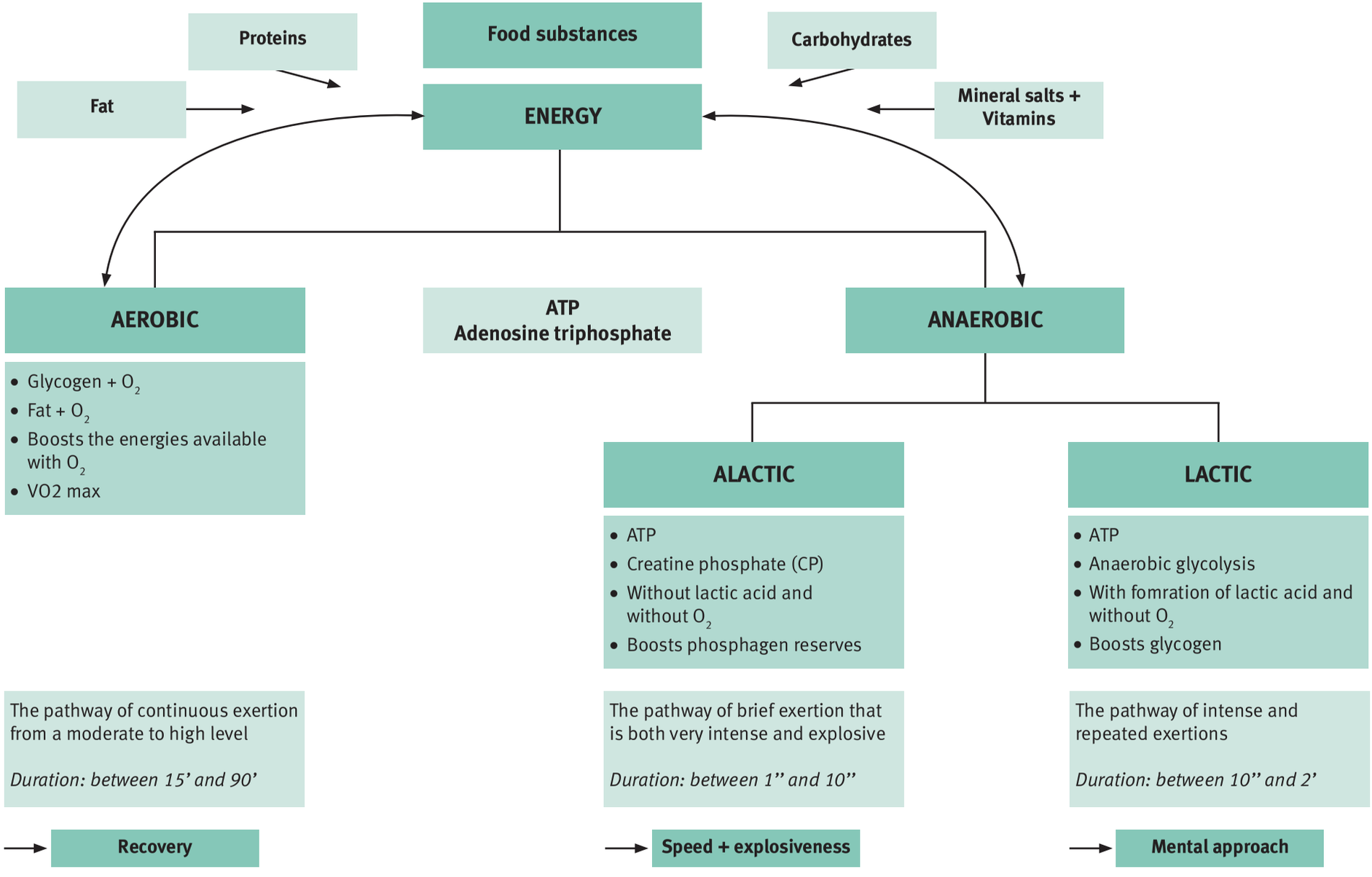
The ATP-CP and glycolytic pathways are the principal sources of energy during the first few minutes of intensive exercise. For longer lasting exertion that requires a considerable supply of energy, the oxidative pathway represents the main source of energy (aerobic metabolism).

Table 5: Energy supply (anaerobic/aerobic)



This system of reproduction functions through the process of the organic qualities by two energy pathways: **the aerobic pathway and the anaerobic pathway.**

Table 6: Energy pathways and the energy system



The effects of endurance training

Aerobic endurance

- Aids recovery in the short and long term.
- Delays the onset of physical and mental fatigue.
- Improves cardiovascular circulation and increases the number of capillaries around and within the muscle.
- Helps to promote deeper, fuller breathing.
- Develops a stronger and more resilient heart.
- Increases glycogen supply.
- Allows the body to burn fat better.
- Eliminates toxins.
- Lowers the risks of injury.

Anaerobic endurance

- Increases the capacity of the phosphate system, thereby delaying acidification of the muscles.
- Helps the player to work intensively and for longer.
- Helps the player to adapt to and tolerate lactic acid.
- Increases work efficiency, especially as far as pressing and intensive long runs are concerned.

What factors influence endurance performances?

Maximum oxygen consumption (VO2max)

As an indicator for assessing the aerobic aptitude and cardio-respiratory endurance of an athlete, VO2max is defined as:

> The maximum volume of oxygen that can be consumed during continuous and gradually increasing intensive exercise, mainly using the aerobic processes. It is calculated in ml/kg/min using specific laboratory tests or field tests.

In some ways, it can be seen as the athlete's equivalent to the cubic capacity of an enghine. Consequently, the larger this cubic capacity is and the more efficiently the player is able to use its contents, the better his performances will be in the match. Top-class athletes have a VO2 max of anything up to 70 ml/kg/min, and even more, depending on the level of endurance called for in their sport. In football today, VO2max has become a reference criterion. Given that the norms vary between 58 and 68 ml/kg/min for top-flight players and even among young players (aged 16-17), a VO2max reading of 60 to 62 ml/kg/min is considered to be good.

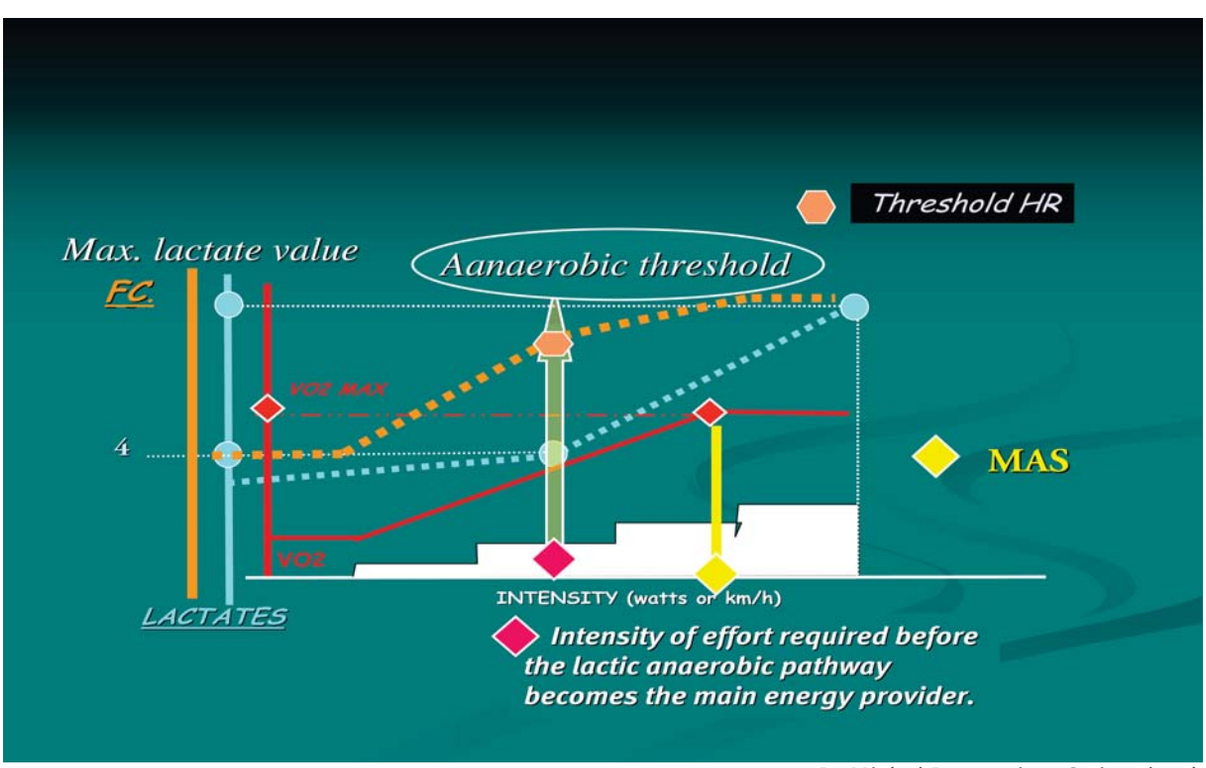
Fast and slow twitch muscle fibres

The proportion of slow twitch (ST) muscle fibres and fast twitch (FT) muscle fibres also has an influence on endurance capacities. Appropriate training can transform the FT fibres into ST fibres; the opposite is also possible, but only to a very limited extent. With endurance training, especially basic training (aerobic capacity) where the FT fibres can "fall asleep", it is advisable to incorporate co-ordination and speed exercises and other reactive exercises at the end of the endurance training session.

The anaerobic threshold

This is an individual value that can sometimes vary considerably. It indicates the lactate (lactic acid) concentration in the blood for a certain intensity of exercise. Up to a lactic acid concentration in the blood of 4 mmol/l, energy is mainly produced aerobically with oxygen present. Above this threshold (the anaerobic threshold), the anaerobic lactic process kicks in. This is where we enter the critical zone of anaerobic resistance, known as the "red zone".

Table 7: The parameters of aerobic capacity



Dr Michel Ramazzina, Switzerland

When an athlete knows his anaerobic threshold and maximum aerobic speed (MAS), it provides him with important reference information that can be used to improve the quality of his endurance training.

Other factors

Thermal regulation (heat production) and fluid loss (lack of water) can also have a detrimental effect on endurance performances and even psychomotor performances (athletes experience a sensation of being thirsty, a quickening of the pulse, cramp, the onset of weakness and start to become overly aggressive, etc.). Ensuring that they drink during training sessions and especially during very hot spells lowers the risk of problems occurring. General health, diet, age and mental approach are also factors that can affect a player's endurance capacity.

The objectives of endurance training

- To increase the maximum oxygen consumption or VO2max.
- To develop the oxygen store (aerobic capacity).
- To improve cardiac output, the player's "turbo" (maximum aerobic power = MAP)
- To push back the anaerobic threshold.
- To develop the heart and the general metabolisms of the cardiovascular and respiratory system.
- To improve the functioning of the aerobic and anaerobic energy pathways.
- To aid the recovery process.

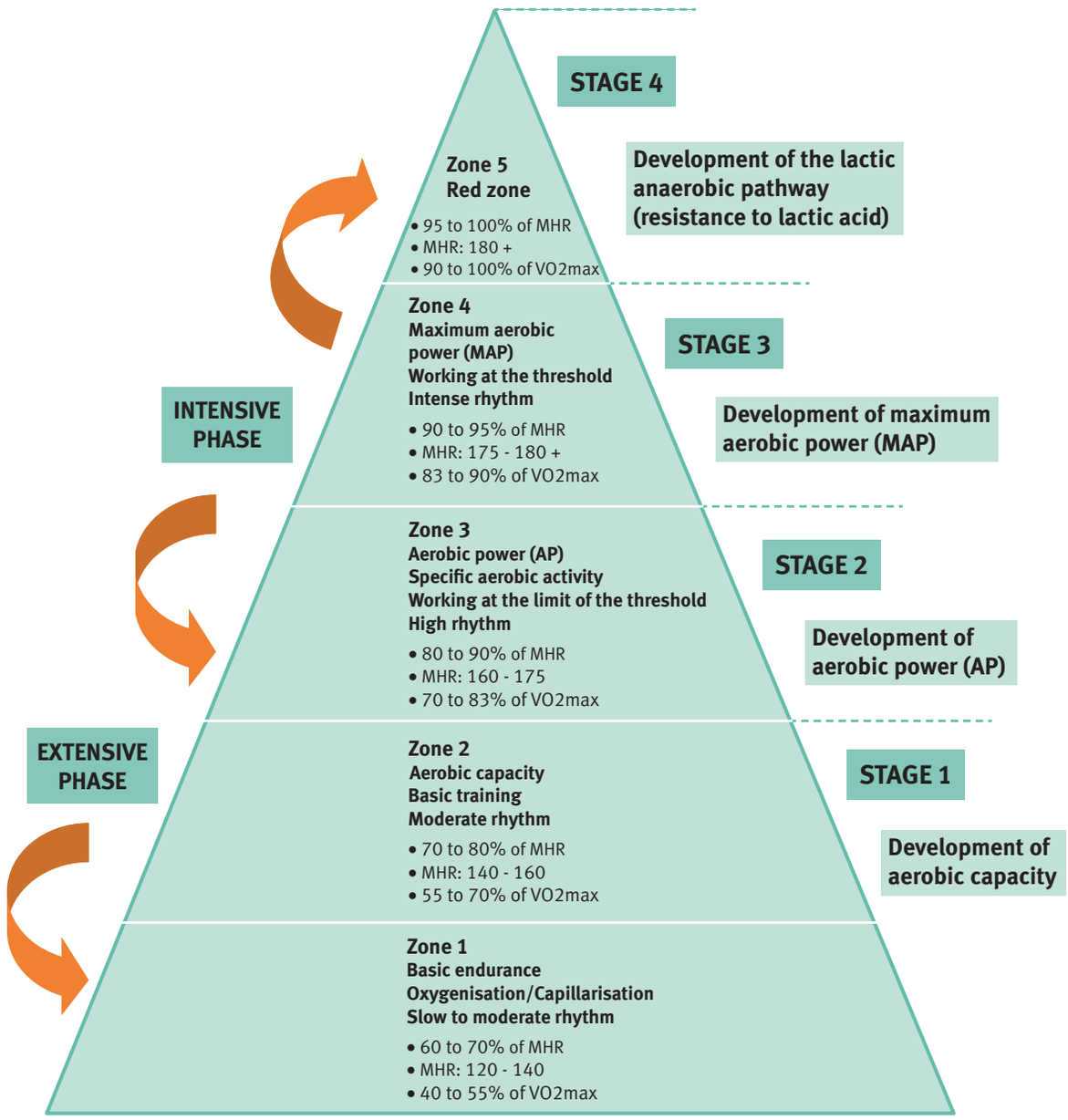
→ Endurance, which is such an important quality in footballers, can be developed in youngsters at a very early age using various forms of training with a ball, or with the help of other sports.

Methods of aerobic and anaerobic endurance training

Table 8 shows the different zones of endurance training and the pyramid of the different stages of development with the properties of the metabolism for aerobic and anaerobic endurance. Depending on the objective of the training, we have defined the "target" training zones that correspond to the level of intensity that is known in advance as a percentage of maximum heart rate (MHR) for basic endurance, for endurance capacity or for power endurance. We feel that knowing these target zones can help to improve the work of the coach in his planning and programming of training.

Example: Training in zone 3 is the phase of specific aerobic training that calls for aerobic power; it is already an intensive first phase in endurance training, but always with oxygen intake.

Table 8: The zones of endurance training



As far as aerobic *capacity* is concerned, the emphasis of the work in the **extensive phase** is on quantity (i.e. long duration).

As far as aerobic *power* is concerned, the emphasis of the work in the **intensive phase** is on quality and intensity of effort (i.e. shorter duration).

The continuous training or long interval training method

Training zones 1 and 2

Objectives

- Basic training
- Endurance (aerobic capacity)
- Oxygenation + Capilliarisation
- Basic aerobic build-up (oxygen stores), thereby allowing the muscles to consume O_2 better

Forms

- Slow to moderate running: jogging, cross-country running (e.g. in the forest for better oxygenisation)
- Running with the ball: passing practice with 2, 3 or more players, etc.
- Technical and technical/tactical drills with movement
- Uninterrupted games (7 v 7 / 8 v 8 / 9 v 9 / ...)

Duration

- Between 20 and 60 minutes (50 mins is the optimum) ⟶ 6 to 12 km

Intensity

- Low; 50 to 70% of MHR (oxygenation and capilliarisation)
- Medium to moderate; 70 to 80% of MHR
- Average heart rate of 120 to 160 beats / min

Alternative

- Continuous exertion (e.g. 30 mins or long-interval training with gradual increase in rhythm: 1 x 10 min at 70% and 2 x 10 mins at 80% of MHR)
- Long interval (e.g. 6 x 1000 m: twice in 5'15", twice in 4'45", twice in 4'30")

The interval training method

Training zones 2, 3 and 4 (depending on the intensity of zone 2)

Objectives

- Extensive endurance (aerobic capacity)
- Intensive endurance (aerobic power and maximum aerobic power)
- Specific endurance (aerobic/anaerobic)
- To push back the anaerobic threshold
- To increase VO2max

Forms

- Interval running (medium and short runs)
- Pyramid runs (e.g. 600m-500m-400m-300m-200m-300m-400m, etc.)
- Technical or technical/tactical drills
- Small-sided games (5 v 5 / 4 v 4 / 3 v 3 / 5 v 4 / ...)
- Games with one team outnumbering the other, or games with only limited touches allowed

Duration

- Between 15 and 30 minutes or 3 to 6 km running (average of 4 km)
- 3 to 12-minute sets, in the form of practice games

Intensity

- High; from 80 to 90% of MHR
- Average heart rate of 160 to 180 beats / min (and more, depending on the player)

Recovery

- Depending on the exertion between repetitions (whether this is active or passive), but heart rate should return to 120-130 beats/min
- 4 to 8 minutes between sets

Being able to switch from one training zone up to the next one (from zone 3 to 4) depends on the extent to which the players have exerted themselves and the recovery time.

The intermittent training method

This is a variation of interval training with alternation between high and slow exertion levels, but where the resting heart rate does not go below 150 beats/min between each high-exertion repetition. This specific method is close to a real match situation and is generally used in periods preceding competition and periods of competition. To boost the quality of this training method, it is beneficial to know the player's maximum aerobic speed (MAS) and/or his anaerobic threshold speed (see table of tests on page 28).

See tables 9a) and 9b)

Training zones 3 and 4

Objectives

- Aerobic power (AP) at maximum aerobic power (MAP)
- To improve anaerobic-aerobic endurance and increase VO2max
- To stimulate the energy pathways and the fast twitch muscle fibres
- To push back the anaerobic threshold
- To improve aerobic speed (endurance speed)

Forms

- Intermittent running training
- Intermittent technical training (running and technical work)
- Mixed intermittent training (low jumps, high jumps, runs, technical work)

See training content

Duration

- 12 to 20 mins total in sets lasting between 5 and 8 mins (depending on the type of training and the type of exertion)
- Active recovery of 5 to 10 minutes between the different sets
- Exertion ratio of 15" : 15" (e.g. 15" : 15" ⟶ 15" slow : 15" high) 10" : 20" / 15" : 30" / 5" : 25")

The degree of exertion expected can be selected by taking the positions of the players into account.

Example: – Midfielders: (15" : 15" / 15" : 30")
– Defenders and outside midfielders: (10" : 20")
– Attackers and central defenders: (5" : 25")

Intensity

- From 85 to 100% of MHR
- Average heart rate of 165 to 180 beats / min

Table 9 a)

interval training

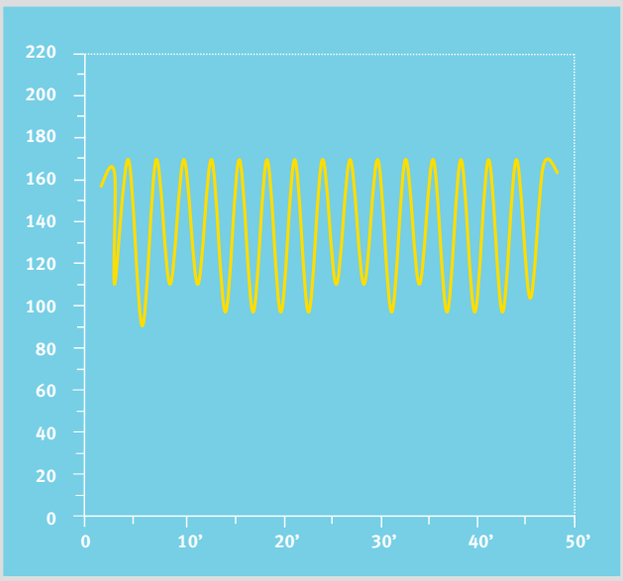
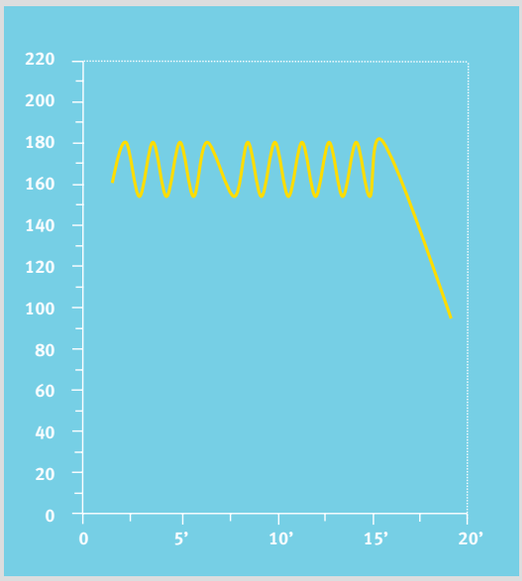


Table 9 b)

intermittent training



Comparison showing the evolution of pulse rates during two different forms of training: Interval training and intermittent training (G. Gacon, 1996).

It can be seen that only intermittent training demands a constantly high level of maximum aerobic power: the heart rate does not fluctuate much within a very narrow bracket that is close to the maximum reading. This is clearly not the case with interval training.

The fartlek training method

Fartlek (a Swedish word meaning "speed game") is considered to be the precursor of the intermittent training system. It includes fast, moderate and slow runs on natural and varied terrain. It could be described as "spontaneous" interval training, given that the periods of work and recovery are not timed precisely. The proportion of fast, moderate and slow runs depends on the athletes, on their particular requirements, their physical state, or on whatever they feel they would like to work on. This method can be used to develop both aerobic and anaerobic capacities, depending on the objectives sought (Fox and Matthews, 1984).

In football, the practice games and training routines where running at different speeds is practised (variable tempo running) can be equated to the fartlek method.

The exercise routine is broken up by changes in tempo (e.g. moderate exertion: 1 minute; slow exertion: 2 minutes; high exertion: 15 seconds; slow exertion: 2 minutes, etc). The fartlek method is often used in a period of preparation alternating with the continuous duration method, or in a pre-competition phase.

Training zones 2 and 3 (and also zone 4)

Objectives

- Basic and specific training
- Endurance (aerobic capacity)
- Endurance (aerobic power)

Forms

- Runs or a variety of obstacle courses, etc., both with or without the ball; cross-country runs, running in the forest, with variation of speed.

Duration

- Between 15 and 30 minutes, with 2 to 3 sets lasting 8 to 15 minutes
- Moderate effort (70%) for 2 minutes and intense effort (80-90%) for 1 minute; or moderate running for 3 minutes and then running at speed for 15 to 20 seconds, etc. (as well as running with the ball)

Intensity

- 70 to 90% of MHR
- Heart rate of 150 to 180 (depending on the objective)

Anaerobic lactic training

Interval training method (short and medium intervals)

Training zones 4 and 5

Objectives

- To get the body accustomed to tolerating lactic acid
- To develop the lactic anaerobic pathway
- Training with reduced oxygen
- Anaerobic lactic speed
- Mental training

Forms

- Runs, sprints, shuttle runs
- Technical or technical/tactical drills where the players are “under pressure”
- 1 v 1 / 2 v 2 / 4 v 4 games (with man-to-man marking)

Duration

- Between 8 and 15 minutes
- Exertion with repetitions lasting from 20 seconds to 2 minutes (the average duration should be 1 minute)
- 1 to 2 sets comprising 3 to 5 repetitions each (depending on the form and the degree of exertion)

Intensity

- High to intense
- 90 to 100% of MHR
- Average heart rate of 175 to 200 beats/min (the HR is very individual)

→ Recovery: – Incomplete recovery between repetitions (HR: 130 - 40)
– Complete recovery between the sets of repetitions (HR: 120 - 110)

Frequency of training (Example)

- Various short-interval repetitions (lasting between 20 secs and 1 min.) to be performed once per week during a competition phase
- Medium-interval repetitions (lasting between 1 and 2 mins) to be performed once every two weeks during a competition phase

Some rules for anaerobic lactic training

- As this type of training is particularly gruelling, both physically and mentally, it is not essential for footballers. Lactic anaerobic pathway training and aerobic power training should always be preferred. It is, however, necessary to go through this type of training from time to time to get the body accustomed to tolerating lactic acid.

- It must be done at the start of the season after 4 to 5 weeks of pre-competition training. If this precaution is not taken, there is a certain risk of injuries, or even a substantial drop in performance after a "promising" start to the season.

  ⟶ The classic drop in form (as a result of over-training)

- It must not be undertaken in the three days preceding competitive activity.

- It leads to depletion of the muscles' sugar reserves. Players must therefore ensure that their diet following such training is rich in carbohydrates to allow them to replenish these reserves.

- It is used especially to train mental approach (with athletes having to experience their own personal limitations).

- **Beware:** This type of training is not suitable for players under 15.

Tips for optimising endurance training

- A constant but careful change in the different training methods and contents of training sessions will have a positive effect on endurance training and on the players' motivation. Given that endurance capacity varies from one player to another and heart rate values are therefore different as well, endurance training also has to be tailored to the individual. It is wrong and also dangerous, especially when working with young players, to force the whole team to follow the tempo set by the player (or players) with high endurance capacity. Youngsters (12 to 15-year-olds) have to be allowed to run at their own tempo. The coach should observe their running, their physical state when exerting themselves, their breathing and their facial expressions; their heart rate should then be monitored. With top-level players who are more advanced in their development, training can be done in groups of players with the same aerobic capacity.

  Experience has shown that it is possible to work with four to five distinct groups by taking into account the results of specific tests, such as the Cooper Test, where consideration is given to distance covered in a specified time or to maximum aerobic speed (MAS). It is also possible to form groups according to the players' position on the pitch, given that there is a direct link between the player's aerobic capacity and his position.

  Example: groups of midfielders, principal strikers or outside midfielders

- Before working on developing aerobic power, it is important to develop basic endurance with training on aerobic capacity (70 – 80% of MHR).

- It is advisable to train at 85 – 90% of MHR (zones 3 and 4) to increase the player's aerobic power capacity and to build up his "engine room".

- To push back their anaerobic threshold, players have to train at the lower limit of the threshold with an incremental increase in workload to achieve maximum aerobic power of 80-85% of VO2max (zone 4).

- A Norwegian study (published in 2001) confirms that there is a 10.8% improvement in maximum oxygen consumption (VO2max), but also a 20% increase in the distance covered in the same time with pure running training at 90 – 95% of MHR with four 4-minute repetitions and a recovery phase of 3 minutes' slow jogging between repetitions. The study was based around two specific sessions of 25 minutes per week held over a two-month period.

- A Swedish study suggests that 3 v 3 practice games with small goals and no goalkeepers can be used as a form of endurance training, especially for working on aerobic power (with HR at 85 to 95% of MHR). These games are played on a reduced-size pitch (33 x 20 m) with a specified work-rest ratio (3 mins : 2 mins; 70 secs : 20 secs; 4 mins : 1 min; ...) and with constant supervision by the coach (who gives instructions, encouragement and restarts play whenever the ball goes out).

  See tables 10 a) and 10 b)

By way of a conclusion, the table showing details of training the metabolism and the energy pathways (page 23) should provide the coach with an overall picture of training methods and the volume of training required to achieve the various training objectives.

Table 10 a)

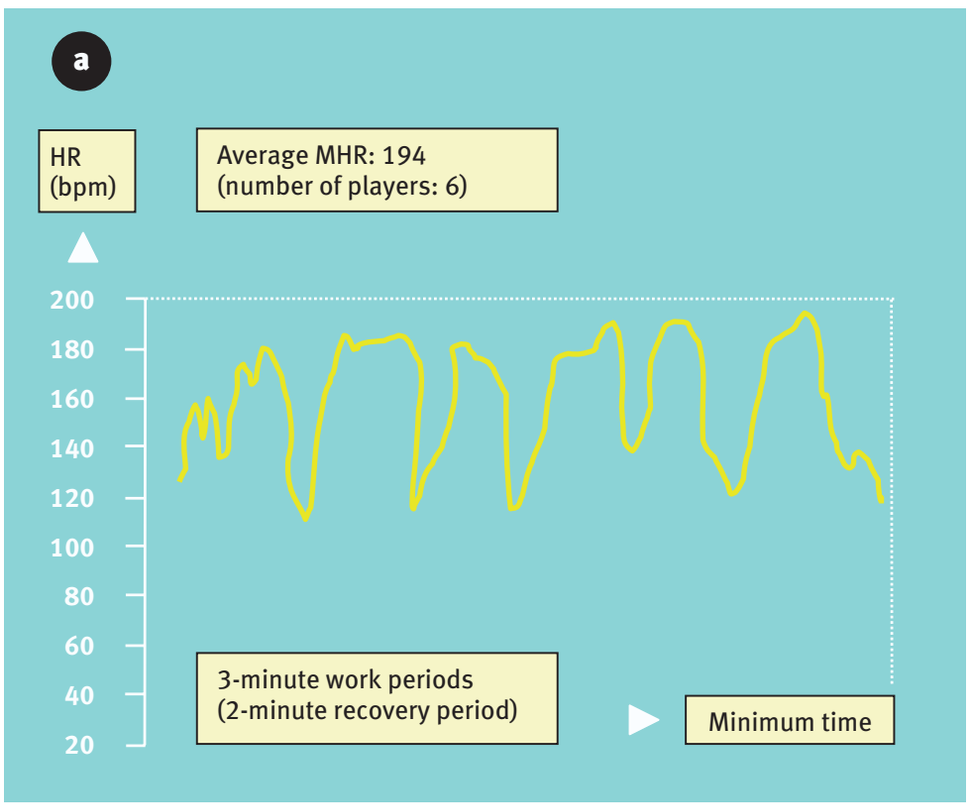
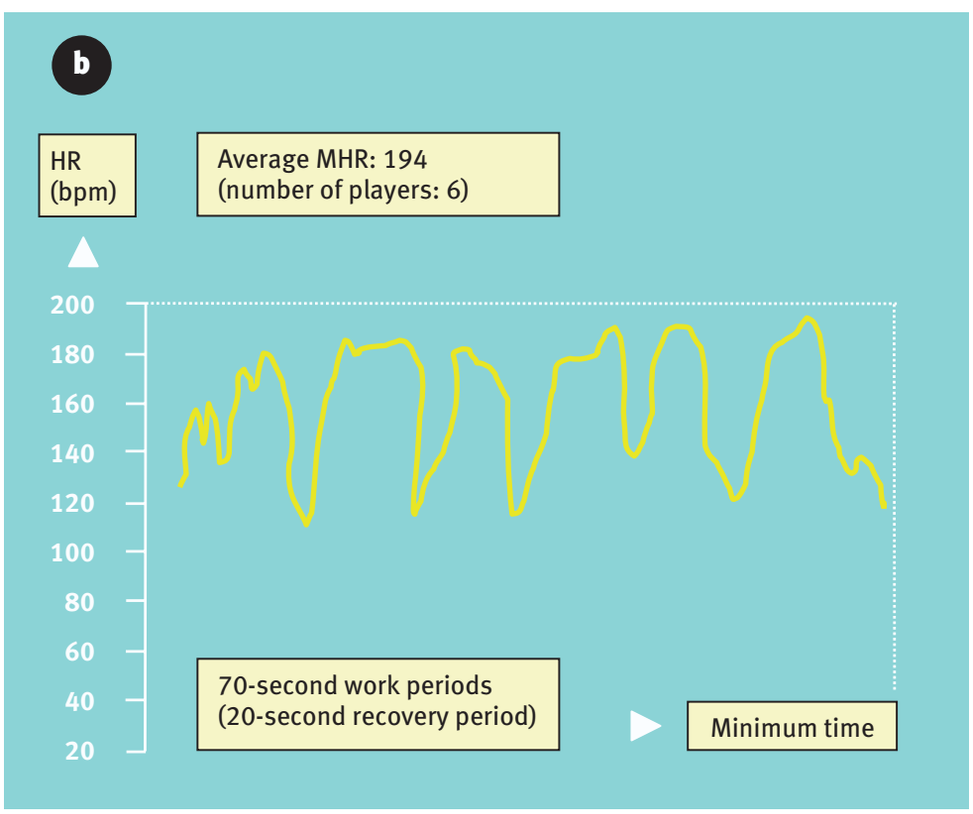


Table 10 b)



Results from two 3 v 3 games on reduced-sized pitches showing the average heart rate of the six players during the match (Dr P.D. Balsom).

TABLE SHOWING TRAINING OF THE ENERGY PATHWAY METABOLISM

Pathway		Aerobic				Anaerobic		
Phase		Extensive endurance		Intensive endurance		Pure resistance (lactic)	Anaerobic alactic	Anaerobic lactic
Objective		Zone 1 Elementary endurance Pure aerobic Regeneration/Oxygenation Capillarisation	Zone 2 Basic endurance Aerobic capacity --› Reservoir	Zone 3 Specific endurance Aerobic power (AP) (Aerobic - anaerobic) --› Anaerobic threshold limit	Zone 4 Maximum aerobic power (MAP) (Aerobic - anaerobic) Onset of production of lactic acid --› Debit	Zone 5 Lactate tolerance (with production of lactic acid) --› O2 debt	Pure speed (without production of lactic acid)	Resistance speed (with production of lactic acid)
Intensity	% of MHR	55% to 70%	70% to 80%	80% to 90%	90% to 95%	95% to 100%	100% of max. speed	95% to 100%
	HR	120 to 140	140 to 160/165	165 to 175/180	180 and more	180 and more		of max. speed
	VO2max	40% to 55%	55% to 70%	70% to 83%	83% to 90%	90% to 100% and more		
Intensity example of 2 players (A + B)	Objective	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5		
	Player	A / B	A / B	A / B	A / B	A / B	A / B	A / B
	% of MHR	60%-70% / 60%-70%	70%-80% / 70%-80%	80%-90% / 80%-90%	90%-100% / 90%-100%	95%-100% / 95%-100%		
	HR	115 to 134 / 120 to 135	140 to 150 / 135 to 155	150 to 170 / 155 to 175	170 to 190 / 175 to 195	178 to 190 / 185 to 195		
	average HR	120 to 140	140 to 160	160 to 175	175 to 190			
Substrates (Lipids = fats) (Glucides = carbohydrates)		Majority of lipids Few carbohydrates O2 intake	Majority of lipids Slightly more carbohydrates O2 intake	Equal share of lipids and carbohydrates O2 intake	Majority of carbohydrates O2 debt	Carbohydrates ATP - CP	ATP - CP	ATP - CP then carbohydrates after depletion
Method		Continuous Long interval Variable tempo	Continuous Long and medium interval Variable tempo	Variable tempo Medium interval Intermittent	Variable tempo Medium and short interval Intermittent	Medium and short interval	Short interval with repetition	Short interval with repetition
Form		Slow running Technical/Tactical exercise Technical circuit course Game	Moderate running Technical/Tactical exercise Game on large or medium pitch Technical circuit course	High-paced running Technical/Tactical exercise Game on small pitch (5v5 / 6v6 / 7v7)	Intense running Technical/Tactical exercise Technical work under pressure Small-sided game (3v3 / 4v4 / ...)	Intense running Sprinting Technical work under pressure Small-sided game (1v1/2v2/...)	Sprinting Low jumps / high jumps Technical drill combinations Running games	Sprinting Running uphill Shuttle running
Volume (Duration)		20' to 60'	15' to 50'	12' to 45'	10' to 25'	8' to 15'	300 m to 600 m	600 m to 1200 m
Duration of effort (time – distance)		Between 15' and 20'	Between 10' and 15'	4' to 12' 800 m to 1500 m	20'' to 4' 100 m to 600 m	30'' to 1'30" - 2' 100 m to 400 m	less than 7'' 10 m to 50 m	8'' to 30'' 50 m to 200 m
Repetitions				2 to 5	3 to 6	3 to 5	4 to 8	3 to 5
Sets		1 to 3	2 to 4	2 to 3	2 to 4	1 to 2	3 to 5	2 to 4
Rest period		Active Return to HR of 120	Active Return to HR of 120	Active – semi-active 1:2 to 1:3 (work to rest ratio) HR of 130-120	Active – semi-active 1:2 to 1:3 HR of 130-140	Passive – semi-active 1:1 to 1:3 Between sets: 10'	Passive – semi-active Return to HR of 110/100 1:10 to 1:20 (1' to 3') Between sets: 5' to 6' / 6' to 10'	Active – semi-active 1:3 to 1:6 Between sets: 8' to 10'

A - Player with high endurance capacity
VO2max: **68**
MHR: **188**

B - Player with medium endurance capacity
VO2max: **57**
MHR: **195**

Training objectives
Improving the transport of O2
Increasing the number and volume of mitochondria
Increasing the myoglobin reserves
Increasing the oxidation of fats
Developing the capillary network
Increasing systolic ejection volumes
Improving VO2max
Helping to save carbohydrates
Increasing the basic metabolism
Using slow-twitch fibres
Aiding recovery

Training objectives
Increasing the anaerobic threshold level
Optimising the improvement of VO2max
Improving and aiding recovery between repeated efforts
Stimulating the slow and fast-twitch fibres
Increasing tolerance to the accumulation of lactic acid

Principles to be observed for training
Training after a rest period
At the start of the session after the warm-up
Adjusted warm-up of 20' to 30'
Intensity and quality
Respect the recovery times
Stretching to aid recovery
Create a competitive atmosphere
Use the ball
Use a starting exercise
Running downhill
Change of tempo and direction
Running exercises and low jumps

Example of how an aerobic training session can be organised

a) Preparation of the session

- **Objectives** ⟶ To develop aerobic endurance with emphasis on technical/tactical aspects.
- **Fix the workload** (% of MHR)
  - Aerobic capacity and power (80 or 90% of MHR)
  - Fix the training zones (zone 2 to zone 4)
- **Forms of training**
  - Running
  - Technical drills
  - Practice games
- **Methods of training**
  - Continuous training (emphasis on duration)
  - Interval and intermittent training
- **Training organisation**
  - Number of players: 18
  - Duration of the session: 90 minutes
  - Total duration of aerobic work: 40 minutes
  - Number of sets: 4
  - Number of repetitions: 8
  - Total duration of rest intervals: 15 minutes ("semi-active" intervals, with ball juggling or another similar simple activity)
  - Composition of the groups: by position (midfielders, attackers, etc.)

b) Training

- **Warming-up with the ball**
  - Duration: 15 minutes
- **1st set**
  - Continuous running
  - Running with the ball fartlek style (30 secs high tempo; 90 secs moderate tempo)
  - Duration: 2 x 8 mins
  - Rest interval: 2 mins
- **2nd and 3rd sets**
  - Group 1 (9 players)
  - Intermittent training: "running and technical work" (10 secs – 20 secs)
  - Group 2 (9 players)
  - Interval training: passing drill with 4 players (30 secs – 1 min)
  - Duration: 6 mins for each drill, with change of groups
  - Rest intervial between sets: 3 mins
- **4th sequence**
  - 4 v 4 practice game + goalkeepers on reduced-size pitches; unrestricted play with goal-scoring
  - Duration: 12 mins; 4 repetitions of 3 mins each – 3-minute rest interval
- **Warming down**
  - Light running and stretching
  - Duration: 10 mins
- **Coaching**
  - Prepare the pitch in advance.
  - Greet the players and let them know the objectives of the training session.
  - Lead, stimulate, reinforce and evaluate (monitor the players' heart rate).
  - Make the players take on fluid during the session.
  - Once the training has finished, assess the session and congratulate the players on their commitment.

4. Evaluating and monitoring the intensity of training

It has been demonstrated that an increase in the intensity of exercise or of a practice game produces a proportional increase in heart rate. Consequently, the higher the player's heart rate, the greater the intensity at which he is working. Monitoring of HR (heart rate) is therefore the most widely recognised and simplest way of assessing the intensity of a training activity.

How to measure heart rate (HR)

- By taking the pulse at the wrist (radial artery) or at the neck (carotid artery) and counting the heartbeats (bpm).

  In general, this is measured over a 15-second period and multiplied by 4
  (e.g. 32 x 4 = 128 bpm)
  or over a 10-second period and multiplied by 6.

- Using a heart rate monitor with a transmitter (chest belt) and a receiver (wristwatch) that indicates the heartbeats on the watch display.

How to monitor maximum heart rate (MHR)

Maximum heart rate is the highest individual heart rate that can occur after intensive exertion. Work intensity is usually expressed as a percentage of the maximum heart rate. Consequently, it is necessary for the coach to know the maximum heart rate of all his players. Given that heart rates differ from player to player, even among players of the same age, the maximum heart rate should be measured by specific exertion tests in a laboratory or on the pitch. Although there are several tests to measure MHR, this can be done simply by making the player do a very intensive run of at least 400 too 500 metres. His heartbeat should then be measured as soon as he has completed the distance, thereby providing a significant MHR reading.

The following is a simple test (devised by Dr Paul D. Belsom, Sweden) to measure MHR on the pitch:

– Normal warm-up, with jogging four lengths of the pitch, or 400 metres, followed by six lengths with a gradual increase in running intensity until maximum speed is reached.
– Sprinting from the third length to the fourth, maximum-speed sprinting to the fifth and sixth lengths.
– As soon as the players finish, their heart rate should be checked immediately by the coaches or fitness monitors. If they have worn a heart rate monitor, the highest rate recorded should be noted as soon as they have finished.

This intensive test can be repeated 2 to 3 times per player over several days to ensure the correctness of the MHR reading. Bearing in mind the intense effort required for this test, however, it should not be performed on the day before or the morning of a match.

Another method

Theoretical MHR, which is known because of its calculation formula (where the subject's age is subtracted from the figure 220), can also be used as a reference criterion for measuring intensity. This method is, however, not particularly accurate, as values differ from player to player, irrespective of their age.

Example: 220 – 21 (age) = MHR of 199 bpm.

How to use the MHR as a basis for planning training work

Given that the work intensity of a player during a training activity is usually expressed as a percentage of the MHR, we have indicated below the mostly commonly used formula for selecting the target training zones on the basis of an MHR that is already known.

Example:
- To train aerobic endurance (80 - 85% of MHR)
- MHR 199
- THR 199 x 0.80 = 159
  199 x 0.85 = 169
- Target rate between 159 and 169 (bpm)

As the coach knows the values for his players, he can check the **THR** (**T**raining **H**eart **R**ate) during training activity. If a player has a heart rate below or above the target rate, the coach can then adjust the intensity of exertion accordingly.

Other methods and formulas to determine training intensity are used in football. These include, in particular, the following methods: maximum heart rate reserve (MHRR), anaerobic threshold, and maximum aerobic speed (MAS). Use of these methods depends on the knowledge and choice of the individual coach and of his backroom staff.

Specific tests to ascertain these reference parameters for training intensity and volume and also to establish the players' performance condition are now being used in football.

The attached table shows tests for measuring physical capacities.

For practical reasons, we have used the well-established Maximum Heart Rate (MHR) method, as outlined above.

Cooper test

For practical reasons of organisation and also because of its proven results, the 12-minute Cooper Test is still considered to be a useful reference test for physical activity, sport in general and football in particular. The Cooper Test consists of running as far as possible in a time of 12 minutes. Once a track has been marked out on the pitch (350 to 450 metres in length), the coaching staff have to count the number of laps completed by the player, as well as adding on the distance run in the last lap. Not only does the scale of value of the Cooper Test allow us to assess performance, by virtue of the distance covered; it also allows us, on the basis of this distance and by using an indirect formula, to work out an approximate value for VO2max and the average aerobic speed in km/h.

VO2max formula

D x 0.022 – 10.39 = VO2max

3220 x 0.022 – 10.39 = 60.45 VO2max

Aerobic speed formula (MAS) in km/h

D x 5 = Aerobic speed

3220 x 5 = 16.1 km/h

(Marella, Risaliti, 1999)

Even though the Cooper test is heavily influenced by the individual player's motivation, by his capacity for development and by his state of fatigue at the time of the test, the results do nevertheless provide us with some significant indications about his performance and, above all, information that allows us to form more equal groups for endurance training sessions.

Table of values from the Cooper Test for athletes who play team games
(Hagedorn and colleagues 1985)

Distance covered	Level of performance
More than 3200 metres	Very good
2801 to 3200 metres	Good
2401 to 2800 metres	Unsatisfactory
2000 to 2400 metres	Poor
Less than 2000 metres	Very poor

"The best and only true test for a footballer is the match itself."
Sir Bobby Robson

Table showing tests used to measure physical capacities

Table showing VO2max (ml/kg/min) and distances covered in metres using the Cooper Test (Litwin J, Gonzalo F.).

This table shows various tests that are used in football to evaluate physical capacities. Some of these tests are applied in the training of players for comparative and educative purposes, or as methods of selection.

Distance covered	VO2max	AEROBIC/VO2max	SPEED	STRENGTH	OTHER TESTS
2800	52.1	**a) Laboratory tests** • Bike and treadmill (Astrand) • Blood sample (LA) (VO2max, anaerobic threshold, threshold speed and MAS, lactates)	• 10 m (1”60 - 1”80) • 20 m (2”75 - 3”10) • 40 m (5”10 - 5”20) • 60 m (6”90 - 7”80) • 4 x 10 m (9” - 10”)	**a) Maximum strength** • Concentric + excentric • Isometric • Cybex	**a) Suppleness** • Flexion of the trunk, the spinal column and the hips
2900	53.3				
3000	55.5				**b) Co-ordination + Speed** • 30-metre slalom run, both with and without ball • Reaction, rhythm, etc.
3100	58.0				
3150	59.1	**b) Field tests** • Cooper (see Cooper test) • Conconi (anaerobic threshold and threshold speed) • Léger (aerobic speed) • Mognoni (anaerobic threshold, threshold speed, lactates) • Probst (anaerobic threshold and MAS) • Gacon (MAS) • Rosenborg’s Endurance Test (endurance level) • 1000 m or 3000 m test (Time and MHR + rest)	**Recommended training times** (Under 16 / Under 18) • 60 m 7”70 - 7”40 • 40 m 5”30 - 5”10 • 30 m 4”15 - 4”05 • 20 m 3”20 - 3”10 • 10 m 1”80 - 1”70	**b) Explosive strength** • Sargent test • Bosco test • Long jump without run-up • Triple jump • Throwing a medicine ball	**c) Anaerobic speed + Recovery** • (9 x 40 metres with a ball + shooting on goal) Exertion time Rest time after 1 min
3200	60.2				
3250	61.4				
3300	62.3				
3350	63.6				
3400	64.7			**c) Other types of strength** • Abdominals, dorsals • Arms (flexion)	**d) Miscellaneous tests** • Personal tests devised by the coach • Tests to determine body fat mass • Anthropometric tests
3450	65.8				
3500	66.9				
3600	69.1				
3700	71.4				

5. Strength

The muscles are the cornerstone of good athletic build for any sportsman, and all the more so for the footballer, who needs strength in every action of the game. He often runs more than 10 km in a match, but also has to do battle with his opponent using his body. He has to sprint on numerous occasions, jump to win the ball in the air or to shoot at goal. A footballer's strength is not limited to his legs; it extends to his whole body. Consequently, the muscles have to be properly developed, and this has to start from a very young age.

The objectives of strength training

- Improvement in the speed of muscle activation ("surge of strength") and in the athlete's predisposition to deliver top-level performance. The development of intramuscular and intermuscular co-ordination represents the functional basis of this. It is reinforced by another decisive mechanism in athletic disciplines, namely plyometrics or reactive strength.

  – Functional and neuronal adjustment
  → Building dynamic and explosive performance potential

- Expansion of energy potential by increasing muscle mass, the basis for new strength development

  – Structural adjustment
  → Building a solid, athletic, muscular basis

- Improvement of the "flow" of energy into the muscles (working on the energy pathways)

  – Energy adjustment
  → The basis for a better muscular output

The development and training of strength in a footballer must be viewed both in terms of quality and also in specific terms if we are seeking to improve the following aspects of his game:

– his speed
– his starting strength
– his jumping strength and his power
– his shooting strength
– his strength in the duel
– his self-confidence
– the prevention of joint, muscle and ligament injuries

The muscle

- 40 to 50% of total body weight is made up of muscle. Each individual has a different ratio of slow-twitch fibres (ST) to fast-twitch fibres, determined by genetic make-up.

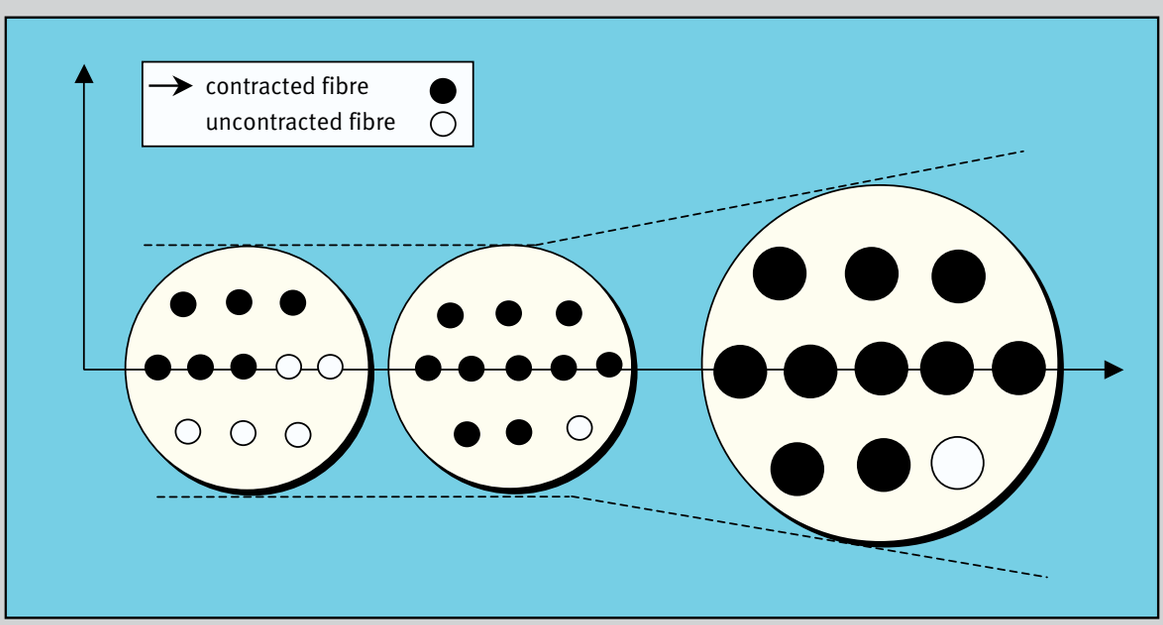
  Muscle contraction is possible as a result of the muscle's fine structure and of the two types of muscle fibre that are classified by the chemical composition of the tissue that reveals various aerobic or anaerobic enzymes.

- Type I slow-twitch red muscle fibres rely almost exclusively on aerobic metabolism
  - These fibres are best suited to endurance sports and are highly resistant to fatigue.

- Type IIA and IIB fast-twitch, phasic or tonic/phasic muscle fibres
  - FTa fibres can be recruited to either an aerobic or anaerobic environment.
  - FTb fibres are essentially geared towards anaerobic adaptations.
  - These are fast and powerful fibres that are not particularly resistant to fatigue.
  - These fibres are best suited to sports requiring speed, strength and explosive strength.

Table 11: The mechanism of strength training

(modified from the original by Fukunaga, 1976)



First comes an improvement in innervation, followed later by muscle fibre hypertrophy.

Table 12: The muscles of the football player

Upper limbs	Torso / Trunk	Legs
• **Pectoralis major** – Shoulder depressor – Adduction of the shoulder	• **Trapezius** – Elevation and adduction of the scapula – Stabilisation of the nape of the neck and the head	• **Gluteals** – Extensor of the thigh (gluteus maximus) – Thigh abductor (gluteus medius)
• **Latissimus dorsi** – Adduction and internal rotation of the shoulder – Adduction of the shoulder	• **Abdominals** – Stabilisation of the trunk – Flexion of the trunk (rectus abdominis) – Rotation of the trunk (external and internal obliques and transversus abdominis)	• **Adductors** – Adduction of the hip • **Psoas major and psoas minor** – Flexion of the hip
• **Deltoid** – Abduction of the shoulder – Elevation of the arm	• **Dorsals** – Stabilisation of the trunk – Extension of the spinal column (nape of the neck, back and lumbars)	• **Quadriceps** – Extension of the knee – Flexion of the hip
• **Biceps** – Flexion of the shoulder – Flexion of the arm		• **Hamstrings** – Extension of the hip – Flexion and rotation of the knee
• **Triceps** – Extension of the elbow – Extension of the shoulder		• **Gastrocnemius + soleus (calf)** – Plantar flexion of the foot – Stabilisation of the knee
		• **Tibialis anterior** – Extension (or dorsal flexion) of the foot

When we execute a movement, we contract one or more agonist muscles while the antagonist muscles (the opposing muscles) are relaxed. Consequently, to bend a leg we have to contract the hamstring muscles and relax the quadriceps.

In training, we always have to bear in mind that we need to provide exercises that work the agonist muscles but without forgetting to introduce other exercises to train the antagonist group of muscles.

Strength training

The three types of strength

Maximum strength

- The greatest strength that a player is capable of producing in dynamic or static form to overcome resistance.

Speed-strength (power/ explosiveness)

- The capacity to mobilise the body and the parts of the body or objects as rapidly as possible.

Endurance strength

- The capacity to resist muscular fatigue in long-lasting efforts requiring strength and endurance.

Strength development and strength training require progressive training of these three types of strength.

Muscular work can be developed in three different ways, depending on the nature of muscular contraction.

The three types of muscular contraction

Isometric

- With static contraction, the length of the muscle remains constant. Muscular tension varies according to the load.

Isotonic

- With dynamic movement, the tension is constant, but the length of the muscle varies.

Auxotonic (plyometrics)

- A combination of forms of contraction, the best known of which are the static and dynamic muscular actions (isometric + concentric work) and plyometrics (a cycle of stretching and thrust jumping).

→ **These muscular actions are the most commonly used in football.**

The different methods of strength training

Maximum strength (intramuscular co-ordination)

- Maximum effort training
- Station training with a personalised programme (with loads)

→ This is an efficient training method for developing speed-strength

Load: 85 to 100% of maximum strength (MS)

Repetitions: 1 - 5

Sets: 5 - 8

Rest interval: 3 - 5 mins between sets

Rapid dynamic execution

Maximum strength (development of muscle volume)

- Repeated effort training
- Station training with a personalised programme (with loads)

→ This is an efficient training method for developing muscle mass and endurance strength

Load: 70 to 85% of MS (for muscle mass)
30 to 60% (endurance strength)

Repetitions: 8 - 12 (for muscle mass)
15 - 20 (and more for endurance strength)

Sets: 3 - 5

Rest interval: 1 - 2 mins between sets

Slow execution or rapid dynamic execution

Speed-strength (power)

- Station training (with loads)

→ This is an efficient training method for developing speed-strength

Load: 30 to 60% of maximum strength (MS)

Repetitions: 6 - 10

Sets: 3 - 6

Rest interval: 1 - 2 mins between sets

Rapid dynamic and explosive execution

It is also possible to do circuit training for endurance strength work (exertion should last between 15 and 30 secs per exercise; with a rest interval of 30 secs)

Reactive strength (plyometrics)

- Multi-jump training (low, high jumps, etc.)
  Selection of different types of jumps and leaps

→ This training helps intramuscular co-ordination, thrust jumping and explosiveness

Load: body weight (plus a light load)

Repetitions: 6 - 12 (4 - 10 secs maximum, depending on the form)

Sets: 3 -5 with the same movement

Rest interval: 1 min after repetitions
3 to 4 mins between sets

Dynamic, explosive execution

This type of training is also possible as part of intermittent training with emphasis on reactive strength and the aerobic pathway

Contrasted strength method

– This specific method features contrasts of loads (heavy and light), alternating between maximum strength work and multi-faceted football-specific and football-orientated exercises

Example: to work on leg strength:
squats (3 x 90% of MS),
followed by six hurdle jumps
and then shooting on goal

→ This training method helps to develop speed-strength

Number of exercises: 3 to 5
(3 x leg exercises and
2 x upper body exercises)

Repetitions per exercise: 2 - 5

Rest interval between repetitions: 1 to 2 mins

Rest interval between sets: 3 to 5 mins

Dynamic, explosive execution

Station training, but also intermittent-type training that calls for aerobic/anaerobic endurance work (depending on the time of the rest interval)

This form of training is easy to hold on the pitch

Electrical stimulation

This modern method consists of working the muscle using electrical stimulation produced by a machine that generates a particular current. This allows a muscle or muscle group to be stimulated in a specific way.

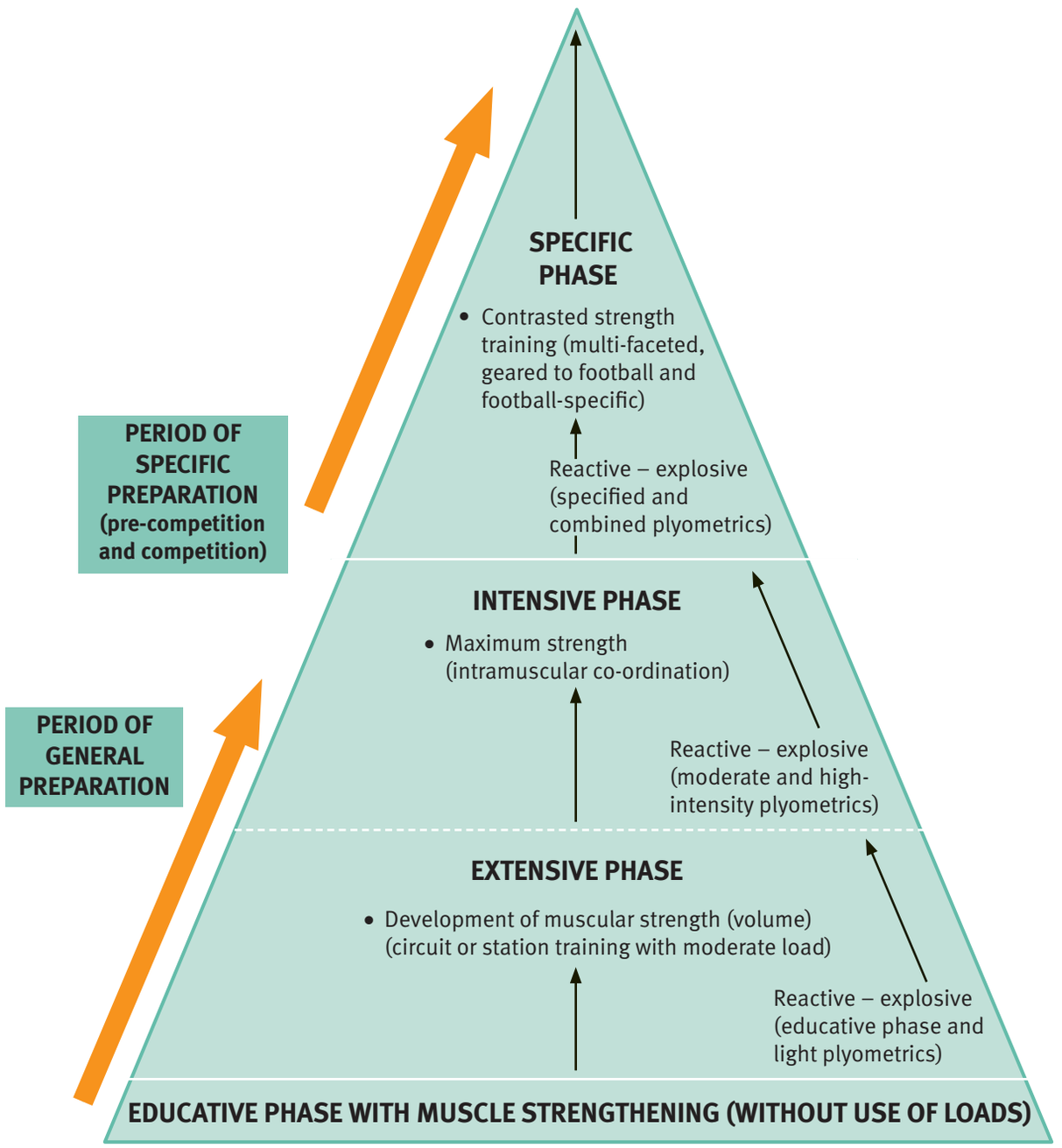
Although it is considered to be an interesting method that can partially replace muscle-strengthening exercises, it does nevertheless have to be used as an addition to muscle training.

It can help to maintain muscle qualities during a period of inactivity (as a result of injury or illness), or during a recovery period.

Generalised muscle strengthening (also known as muscle conditioning) where body weight is used, is the form currently being used throughout the season, and even at every training session, especially for the musculature of the trunk. This “traditional” method is used in particular with youngsters and injured players as an educative phase for strength training (endurance strength: 20 to 40 reps, 2 to 4 sets, with dynamic execution).

In the training content for strength training, you will find various examples of the most commonly used methods in football.

Table 13: Building up strength



Recommendations for strength work

- The development of strength in footballers comes through good general muscle development based on the strengthening of agonist and antagonist muscles, thereby ensuring perfect muscle balance. This is particularly important in young players before they undergo strength training.

- **In the extensive phase:** we are aiming above all for general development of the musculature that acts on the passive locomotor apparatus and ensures good overall balance for the more specific development of football-specific abilities. This stage of basic strengthening is the ideal moment for introducing specific muscle strengthening that is linked to the development of co-ordination skills, in particular orientation, differentiation and balance. It is an educative and elementary phase for muscle development, with work on strengthening muscles using the player's own body weight (muscle conditioning), then gradually progressing to the use of light loads of between 30 and 70% of maximum strength (MS). This type of strengthening is therefore included in the extensive phase of preparation of the footballer, but it may also be extended if the player has not yet reached a satisfactory level of muscular development.

  The following are some recommendations for drawing up the training programme:

  → This training can be held in the form of circuit training (15 - 30 secs / 2 - 3 sets per exercise), or of "station work" (3 sets of 10 repetitions each at 50 - 70% of MS). This can be followed by work in the maximum strength zone (intramuscular co-ordination = IM); such work must be absolutely safe to ensure that there is no overloading. Whereas this work does not pose a risk for the upper body, more attention has to be paid with work on the legs (squats), where the load should not exceed 80% of MS (approx 8RM). Only use of a leg press allows maximum strain.

  → For each anatomical function, exercises have to be chosen that work both the agonist and antagonist muscles and muscle groups to prevent any muscle imbalance, with corrective exercises included as well, if necessary. The exercises selected will cover all parts of the body (lower and upper limbs and the trunk). In this extensive phase, we feel it necessary to schedule two muscle-training sessions per week (e.g. Monday and Thursday, or Tuesday and Friday), especially during a preparation phase or when doing basic muscle building work with youngsters.

- In the intensive phase: the loads are increased gradually, while the volume of training is decreased. With the circuit training, for example, the exertion / recovery times change to 20" – 40", and for the station training the number of repetitions will change to between 5 and 10.

  → Training of thrust jumping ability or reactive strength (plyometrics) will also be introduced into training microcycles in the extensive and intensive phases. This training will be extremely varied and will gradually progress from barefoot work on the floor or on a soft mat (low jumps) with more demanding permutations (using obstacles), to work on harder surfaces (a football pitch). This type of work should be done at least once per week, either in isolation or combined with intermittent work.

- **In the specific phase:** it is imperative that muscle training is continued at least once per week (at the start of the week) to preserve good muscle tone during the long period of competition.

  This can take the following forms:

  → Station training, alternating between heavy and light loads (contrasted method) in functions specific to footballers.

  → Circuit training (15 – 30 secs), also with alternation between heavy and light loads.

  → Combining circuit-strength-training (20 – 40 secs) for the upper body and the trunk with plyometric work (different forms of jumping) for the legs (coaches should insist on very dynamic execution).

  → During this period, emphasis will be placed on mixed intermittent training (5" – 15" or 10" – 20"), with three 6-minute exertion periods and 3 to 6 minutes' rest interval), with the aim of developing resistance speed.

  → As far as incorporating work on strength, power and reactive strength (acyclic speed) into the micro-cycle of training is concerned, we suggest that work which alternates between heavy and light loads (strength and power or reactive strength) should be scheduled at the start of the week. Work that alternates between power and speed or reactive strength should be held in the 2nd part of the week, thereby ensuring excellent muscle tone for the weekend's matches.

In summary, then, training with the right combination of strength development and everything associated with that (power, reactive strength or cyclic and acyclic speed) with specific football-related work will guarantee both the physical integrity of the player and also a high quality of performance.

Table 14: Example of scheduling for strength training

Preparation phase	**(Extensive phase)**		
• 1st week	1 to 2 sessions	2 sets	
• 2nd week	2 sessions	3 sets	
• 3rd week	2 sessions	3 – 4 sets	
• 4th week	1 session	2 – 3 sets	• Cycle with decreased loads
Pre-competition phase	**(Intensive phase)**		
• 2 weeks	1 to 2 sessions	2 – 3 sets	• Increased loads
• 1 week	1 session	2 sets	• Cycle with decreased loads
Competition phase	**(Specific phase)**		
• Each week	1 to 2 sessions	2 – 3 sets	• Cycle to maintain strength

It should be noted that strength training can easily be incorporated into a training session that has other objectives.

Example: It is ideal to hold a training session that concentrates primarily on technical skills after a strength training session.

The invigorating effect of training to strengthen the muscles can have an extremely positive effect on the players' vigour in the technical training work that follows on from that strength work.

Example of a weekly cycle of strength training (during a competition phase)

1st day's training (post-match)

→ Recovery work and preventive treatment work

By: Muscular strengthening and stretching with endurance work (aerobic capacity)

2nd day's training

→ Improving or maintaining both general and specific strength

By: Circuit-strength training or station work (depending on the strength cycle that the players have reached)

4th or 5th day's training (on the eve of the next match)

→ Toning and reactivity

By: Work on power, reactive strength and a combination of cyclic power-speed work (speed) and acyclic work (low jumps)

Example of a muscle building programme for youngsters (15 – 16 years of age)

Cycle 1 / Preparation period (Educative phase lasting 3 weeks)

- **Muscle strengthening**
  - Using body weight
  - Work followed by an obstacle course routine or co-ordination workshops (working on technique)

  2 - 3 sessions per week

Station/circuit training

Load:	body weight + loads (light)
Repetitions:	10 - 20 x
or duration:	20" - 45"
Sets:	2 - 3
Rest interval:	40" - 1' between sets
Execution:	dynamic

- **Reactive strength (plyometrics)**
  - Jumping (low jumps)

  Serves as an additional session to the muscle strengthening

  Example: 2 muscle strengthening sessions and 1 reactive strength session per week

Sequence of exercises

Load:	body weight
Repetitions:	6 - 10 per exercise
Sets:	3 - 4 per exercise
Rest interval:	30" between exercises 1' - 2' between sets
Execution:	dynamic, explosive
Organisation:	5 to 6 different exercises

Cycle 2 / Preparation period (Extensive phase lasting 5 to 6 weeks)

- **Muscle power (speed-strength)**
  - Using circuit training (3 weeks)
  - Using station training (3 weeks)
  - Work followed by co-ordination workshops and technique work

  1 to 2 sessions per week

Station/circuit training

Load:	30 - 50% of MS
Repetitions:	10
or duration:	15" - 30"
Sets:	3 - 4
Rest interval:	45" - 1' between sets
Execution:	dynamic

- **Reactive strength (plyometrics)**
  - Running, sprinting
  - Jumping (medium-height jumps)

  Serves as the 2nd session each week

Sequence of exercises

Load:	body weight
Repetitions:	6 - 10 per exercise
Sets:	3 - 4 per exercise
Rest interval:	30" between exercises 1' - 2' between sets
Execution:	dynamic, explosive
Organisation:	5 to 6 different exercises

Cycle 3 / Competition period (Specific phase lasting 5 to 6 weeks)

- **Contrasted strength + multi-faceted training specially geared to fooball**
  - Change the forms of training each week
  - Intermittent training every 2 weeks

  1 session per week

Station training

No. of exercises: 4 (legs, feet + arms)
Repetitions: 3 - 4 per exercise
Rest interval: 1' between reps
3' between sets
Execution: dynamic

- **Speed, jumping + sprinting and technique**

  Serves as the second session every week

What each exercise consists of

Series of jumps and sprints with shooting on goal

Cycle 4 / (Decreased-load cycle lasting 2 to 3 weeks)

- Complementary activities (other sports / selection of games)
- Obstacle courses (intermittent)
- General muscle toning (with body weight)

  1 to 2 sessions per week
- Suppleness training

Cycle 5 / (Extensive phase lasting 6 weeks)

- Muscle development
  - Using an individual programme (1 session per week)
- Reactive strength (plyometrics)
  - Multi jumps
  - Running, co-ordination drills

The programmes and the loads have been adjusted to suit the players on the basis of their athletic potential, their morphology and the experience they have already acquired in training.

Beware! Strength training using loads that have not been properly adjusted may result in injuries, especially tendon, ligament and muscle tissue injuries.

How to ensure good strength training

Remember the basics in training

- There can be no strength training without a good-quality warm-up
- It is important to develop both the agonist and the antagonists muscles and muscle groups
- There can be no muscle strengthening without stretching
- Cooling-down and a final stretching routine are a must
- To ensure that the players derive maximum benefit from a muscle-strengthening programme, and to guarantee that the programme is an efficient one, the coach needs to assess and adjust the programme from time to time

6. Speed

Speed is one of the key factors in football that results from good physical condition. In the course of a match, a player has to make 100 to 150 sprints, ranging from 10 to 40 metres in length (the average length is around 20 metres). Indeed, for some, speed is the "noblest" of all the skills possessed by footballers. Players are very often forced to sprint, to dummy at speed and make decoy runs, although seldom in a straight line but still at full speed. They also have to use this pace when controlling the ball or shooting at goal. These high-speed actions are all closely linked to strength and to co-ordination.

Anatomical and physiological aspects that have an influence on speed

- Type of musculature: Fast-twitch fibres
- Muscular strength and elasticity
- Availability of energy: energy-rich phosphate (from 0 – 20 secs); anaerobic glycolysis (from 20 to 50 secs)
- Neuromuscular processes and co-ordination skills
- Anthropometric factors (size, weight, morphology)
- The player's mental state, his level of fatigue and how well warmed up he is

The different types of speed required in football

- Speed of perception, anticipation and decision: cognitive elements that allow the player to act and react before opting for his next move
- Speed of reaction: reacting to a signal (acoustic or visual)
- Starting speed: speed-strength, the first strides of a run
- Speed of execution (with or without the ball): the ability to move and change position on the field at high speed (both with and without the ball, as part of a technical move)
- Speed of acceleration: the main quality required by a player seeking to counter-attack or to increase the tempo of play
- Endurance speed: the capacity to maintain maximum speed over a long distance

  Example: An outside defender makes a run into space deep in the opponent's half, then has to run back to his own zone at high speed (a run of around 60 to 70 metres).

Training methodology

Given that the distances run at maximum speed in a football match range between 10 and 40 metres, the principal energy source is the alactic anaerobic pathway. For the longer distances, between 60 and 100 metres, the lactic anaerobic pathway provides the energy.

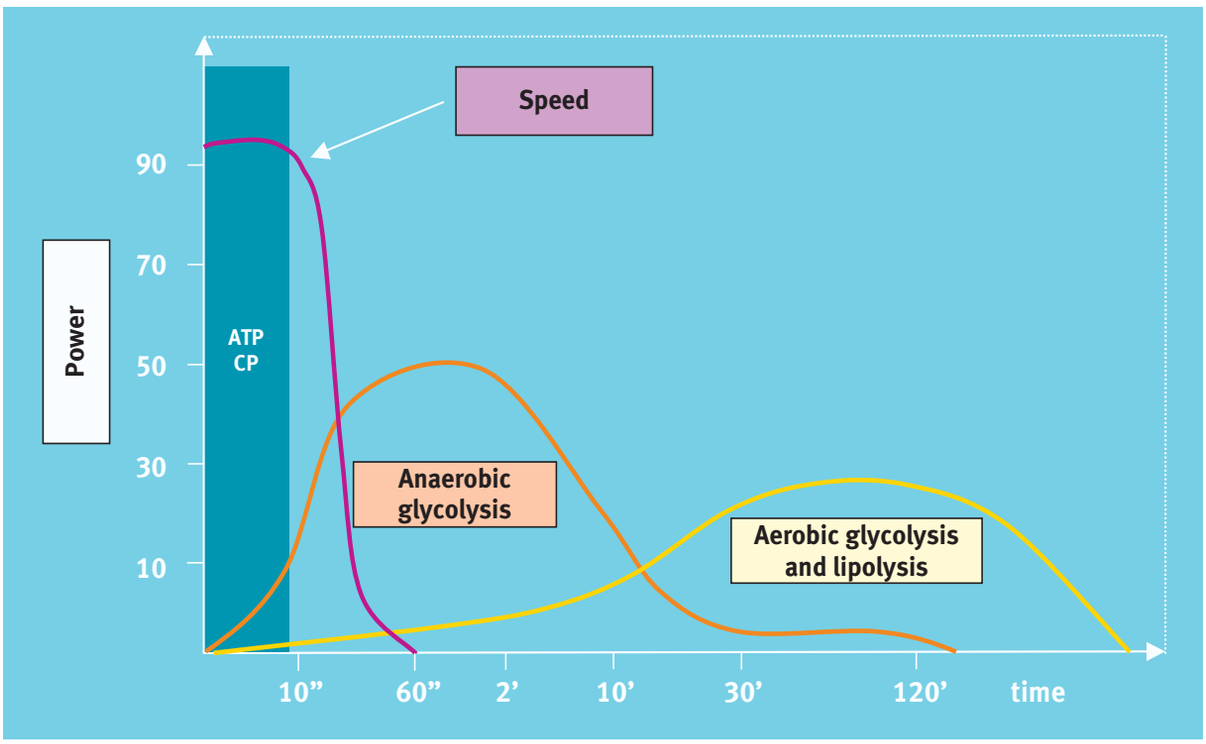
The diagram below shows how the energy pathways function.

Alactic anaerobic pathway
Intense effort lasting 2 to 8 seconds

Lactic anaerobic pathway
Intense effort lasting between 10 and 20 seconds, and up to 30 seconds

Table 15: Howald's curve

(Dr Hans Howald, Swiss Federal Office of Sports, Magglingen)



Training of anaerobic alactic speed, sprinting speed, starting speed, and speed when running with the ball and changing direction, etc., is extremely important in the preparation of players (but over short distances (10 – 20 metres) when working with youngsters).

Even though anaerobic lactic speed (endurance speed) plays only a secondary role in football, it is nevertheless necessary to introduce maximum efforts of between 10 and 15 seconds into the training session. This type of lactic training (which is also called resistance capacity) will allow the player to prolong his phase of maximum intensive effort, while also helping to work on the metabolism.

This type of training is held with a specified integrated format and can also be geared to training for individual positions.

Example: Training for the outside midfielders and defenders with a combination of simple attacking play and running back to defensive positions at full speed.

The form of speed training with separated elements (running exercises, speed co-ordination, maximum starting speed and sprinting speed) is frequently practised with young players, especially during the learning phase. This form of training helps to develop maximum intensity speed, muscular strength and mental approach.

Nevertheless, the integrated form of training (speed + technical work, speed + technical/tactical work), which helps to develop overall co-ordination skill, is essential in training. It enables players to apply maximum speed - the optimum speed for a footballer - to individual and collective actions in the game.

It is important to strike the right balance between these two forms of training to ensure that both are included in the speed training session in equal measure.

Other methods of training

- Progressive runs with changes in tempo and direction, both with and without the ball
- Uphill running (working on power) and downhill running (working on co-ordination), with weights attached as well
- Exercises working on starting speed, practising runs into space, and on speed of reaction when playing out of position, with auditory and especially visual signals
- Competitive exercises in pairs or teams: tag, relay runs, obstacle courses and speed games
- Running exercises with skipping, work on fast footwork and jumps
- Use of a stopwatch to stimulate players (competitive element) and use of tests to motivate them

The right amount of speed work

- The number of repetitions per set, depending on the distance run, should not exceed 4 to 6 (with an absolute maximum of 8) to prevent the build-up of lactic acid.
- The number of sets is dictated by the depletion of muscle reserves. For a distance of 30 to 40 metres, 3 to 4 sets would seem to be the ideal recommended amount. For shorter distances, between 10 and 20 metres, it is possible to do as many as 5 sets.
- The rest period between repetitions must be between 20 and 30 seconds to allow recovery of half of the alactic anaerobic reserves. Although it can go up to 3 minutes, it should not exceed this amount as the capillaries start to close up, thereby eliminating the benefit of the training session (performed at submaximal speed).
- This recovery time is often expressed as 1:10, 1:15 or 1:20; in other words, 10 or 20 times the exertion time. It varies according to the exertion time, the metabolic objective of the training, the training condition of the players, and also on their age.
- The rest period between repetitions is very often active, with some walking or jogging around, depending on the distances run or the duration of effort. As there is a high lactic acid build-up (often more than 5 mmol/L) in the muscles, a minimum rest time of 4 to 5 minutes is necessary, going up to 8 to 10 minutes, depending on the loads. This recovery phase often consists of work on suppleness and simple technique as the basic contents.

Planning of speed work

There has to be follow-up with speed training in the annual training schedule, in the same way as there has to be with work on technique, thereby ensuring that the speed work has a positive effect on all speed-related elements.

- In the phase of preparation for speed work (the "pre-speed phase"), time is spent on developing muscle capacities (agonist and antagonist muscles/muscle groups), on co-ordination, but not too much on aerobic endurance (which relies on the oxidative energy pathway).
- Muscle toning prior to speed training aids muscle contraction and helps work on acting and reacting. The current trend is to hold a strength training session before speed training, using a heavy-light load alternation (strength transformation). This format also boosts the potential of the co-ordination process.
- Speed training is quality-dependent work that calls for great mental commitment (concentration, attention and willpower) and a high level of motivation, hence the importance of introducing a variety of forms of training.
- Speed training must always be rounded off with limbering-down exercises and stretching.
- Two sessions for working on specific speed are usually programmed into the weekly training cycle: at the start of the cycle, emphasis should be placed on speed of execution (alactic anaerobic or lactic anaerobic pathways); at the end of the week, work should focus on reactive speed (reaction and liveliness).

The duration of the speed training session and its content are determined by the other speed-related training elements that are scheduled. Experience has shown that when a speed training session precedes a technical session, the quality of the latter is enhanced because of the demands placed by the speed work on the players' co-ordination capacities (and the players are able to apply these abilities elsewhere, too).

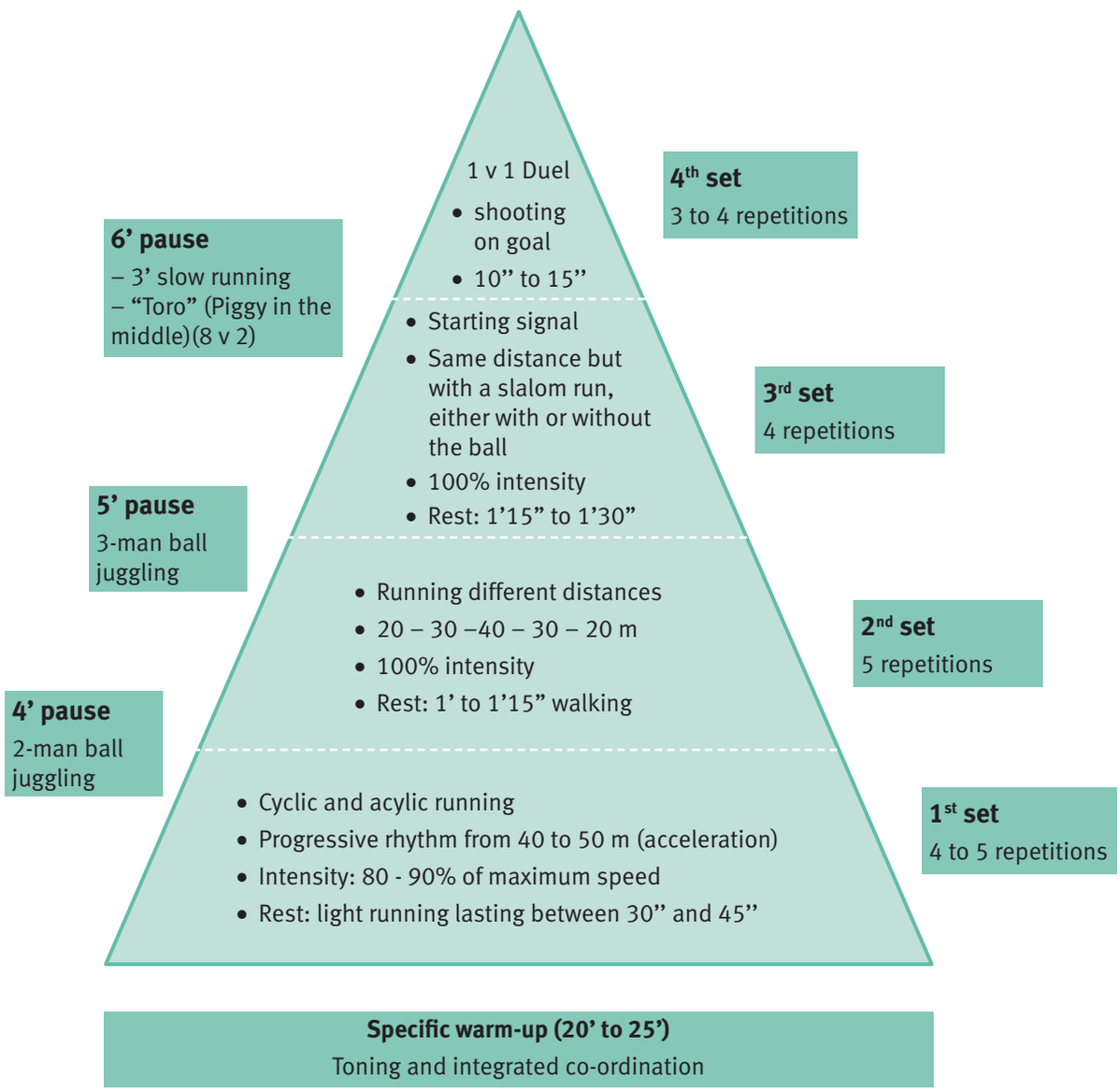
Some rules for speed training that must be respected

- Speed should be trained after a rest period and at the start of a session.
- The speed training session should be held under conditions where motivation is high and where there is total mental focus (to aid concentration, willpower and attention).
- The warm-up should be adapted (muscle stimulation and limbering-up, based on separate and integrated co-ordination).
- Always aim for optimum-intensity work, with the emphasis on quality (submaximal, maximal and supramaximal running).
- The duration of an exercise should not exceed 7 to 8 seconds, or 5 to 6 seconds for youngsters.
- It is imperative that the recovery period is observed and that the content of this period is always planned.
- The forms of training should be varied; running exercises, contests, games (with duel situations in pairs to increase motivation and produce maximum intensity).
- Speed training that goes on too long leads to a build-up of fatigue, increases the risks of muscle and ligament injury, and also impairs the correct execution of skills.
- Light relaxation and recovery stretching exercises are obligatory at the end of a speed training session.
- The organisation of the training session and the quality of the coaching are determining factors in ensuring a good session.

Table 16: The structure of a speed-training session

	ALACTIC ANAEROBIC SPEED	LACTIC ANAEROBIC SPEED
METHOD	Repetitive short interval training	Repetitive short and medium interval training
INTENSITY	• 95 to 100% of maximum speed • Maximal / Supramaximal	• 90 to 95% of maximum speed • Submaximal / Maximal
REPETITIONS	• from 4 to 8 per set	• from 3 to 5 per set
DURATION OF EFFORT	• from 2'' to 8'' (maximum 10'') • 10 to 50 metres	• from 9'' to 20'' • 50 to 150 metres
SETS	• from 3 to 5	• from 2 to 4
TOTAL DISTANCE	• from 300 to 600 metres per session (depending on the training)	• from 600 to 1200 metres per session (depending on the training)
REST PERIOD	• semi-active /active • 1:10 à 1:20 between repetitions (depending on the duration) • 4' to 8' between sets	• active (constant) • 1:3 to 1:6 between repetitions (depending on the duration) • 7' to 10' between sets

Table 17: Example of a speed-training session



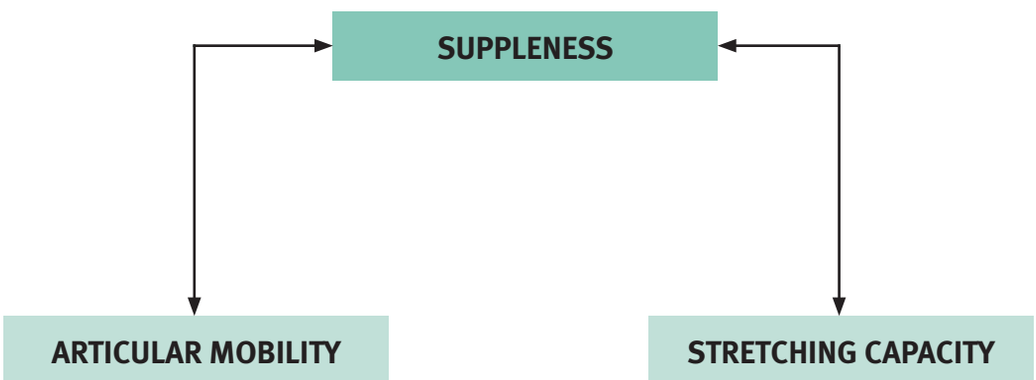
Note: The 3rd set can also be combined with integrated exercises using a ball.

Example: – A 1-on-1 duel exercise, finishing with shooting at goal
– A 3-player counter-attacking move, finishing with shooting on goal (duration 8" to 10")

7. Suppleness

Suppleness is the ability to execute as large a range of movements as possible with ease.

It is determined by two factors:

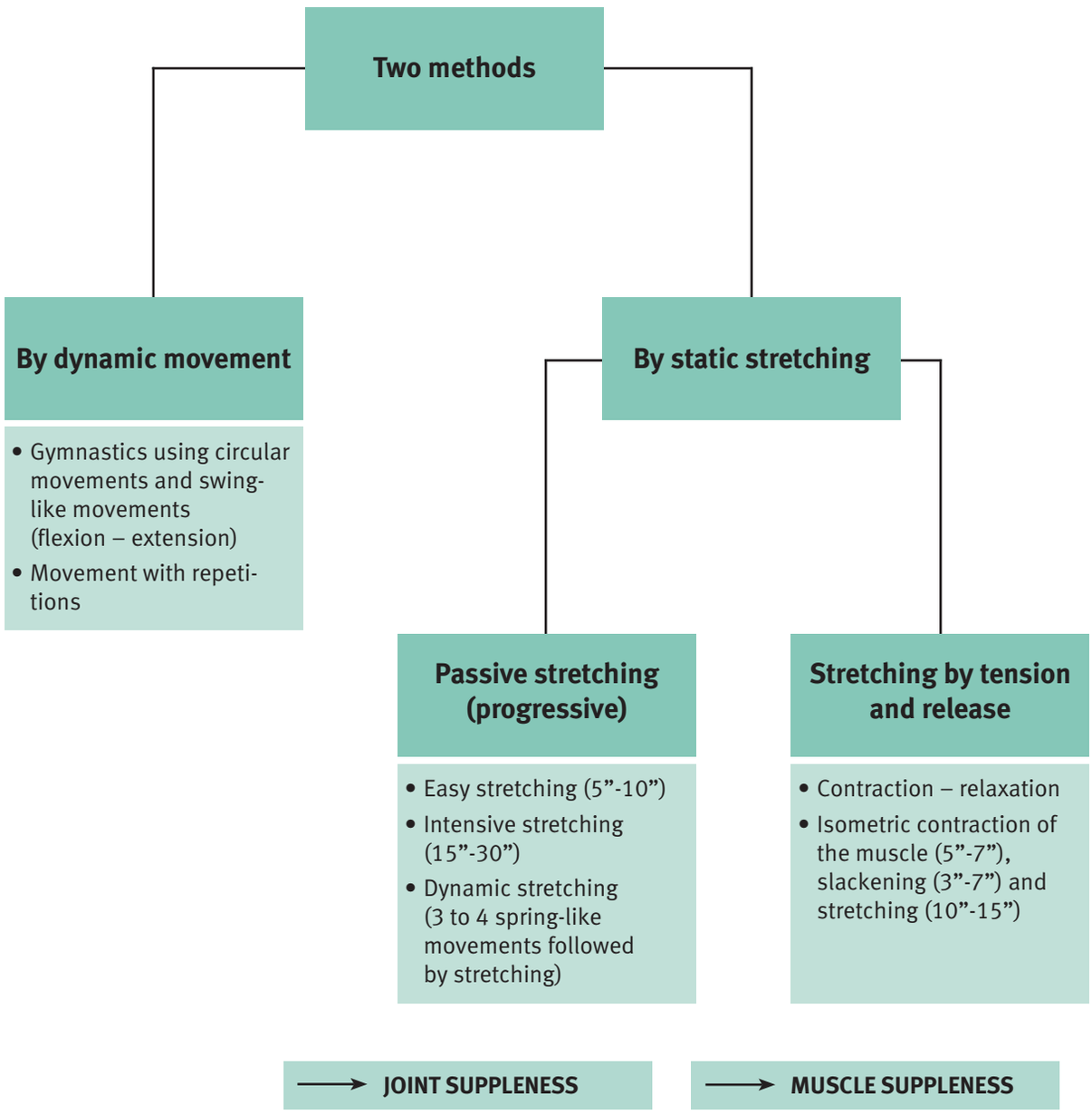


Articular mobility refers to the joints and to the intervertebral discs. Stretching capacity concerns the muscles, the tendons, the ligaments and the articular capsules.

Age, the hormone system, temperature, the time of day, and fatigue all have an influence on suppleness.

The importance of suppleness is greater in a sport such as gymnastics than it is in football. Although suppleness is called for when players shoot, control the ball or feint, the range of suppleness required is not that great for these particular movements. Where suppleness does retain its importance for a footballer, however, is with the prevention of injuries, with the greater elasticity of muscle tissue that it engenders, and also with the fact that a supple player will have a body well prepared for performance.

The methods and forms of training for suppleness



These two methods are compatible in the training of footballers, and are recognised as improving and maintaining suppleness, as well as being an aid to recovery.

Suppleness training should be included at every training session, during warm-up and/or cooling down. Moreover, it should be incorporated in the overall training programme at least twice per week and should last around 10 to 15 minutes.

Stretching alone is not sufficient to improve suppleness; it has to be supplemented with dynamic suppleness training (mobility and flexibility work).

The movement (mobility) method for limbering up

For:	– Spinal column – Torso – Hips – Legs – Feet
Repetitions:	– 10 to 30 (8 to 10 with a minimum warm-up)
Sets:	– 1 to 3

A distinction should be made between dynamic, active movements and sudden, rapid movements.

The static stretching method

This is the most frequently used form of warm-up. It consists of stretching the muscles, slowly and gradually, until they reach the point of tension that needs to be maintained.

Shortening of the muscle groups as a result of effort can have adverse effects on the joints and can, in particular, lead to overloading of articular cartilage. Tendon insertions of shortened muscles often react by becoming inflamed. There is a risk with contracted and contractured muscles that are not readily extensible that they can become elongated or, worse still, torn.

With high-quality stretching, the muscle can regain its firmness and suppleness	
For:	– Muscle groups that are used
When:	– During warm-up – After each training session, in the cool-down phase – After intensive efforts (where speed and strength have been used) – To improve suppleness (mobility)
Duration of tension:	– From 5” to 10” (easy stretching) during warm-up – From 15” to 30” (intensive stretching) during recovery or muscle
Repetitions:	– 1 to 3, depending on the tension duration and the muscle being stretched
Rules:	– No sudden movements – Players doing stretching must always breathe correctly, i.e. regularly and calmly – Players must be fully concentrated – Players with muscle pains should not do stretching – Players should not do stretching before executing explosive movements; this can result in a drop in performance level

Recent studies have shown there is no conclusive proof that stretching has a preventive effect as far as injuries are concerned; the same cannot be said, however, for good basic aerobic endurance.

Stretching is not essential for prepubescent youngsters. Nevertheless, as a way of getting young players used to the idea of stretching, it is advisable to introduce it two to three times per week at the end of training, from the age of 9-10 onwards.

8. Co-ordination skills

Co-ordination skills, which are also described as “agility”, “dexterity” or psychomotor skills, allow the player to control and adjust his movement and to master technical and technical/tactical skills and moves more swiftly.

→ Co-ordination lies at the root of all skilled technical moves

Factors that make up co-ordination (O.R.D.E.R.)

Orientation

The ability of a player to position himself correctly in terms of both space and time.

Changing and readjusting the position of the body on the basis of the perception of a given situation.

Reaction

An ability that allows the player to respond extremely quickly to signals and to match situations.

Not merely executing the right technical move, but also doing so very quickly.

Differentiation

An ability that allows the player to deal in different ways with the information that he perceives with his sensory organs.

Executing individual skills that form part of a team move.

Knowing how to weight a pass correctly.

Equilibrium (balance)

The ability that allows a player to maintain his balance during an action or while executing a technically move.

Being able to regain his balance after a duel, a body charge and after feinting.

Executing the fast footwork required in technical moves.

Rhythm

The ability that allows the player to execute movement rhythmically.

Alternation between speed and slowness.

Dribbling, feinting.

Co-ordination training

Although training of co-ordination skills is appropriate for adult players, it is particularly beneficial with young children whose nervous system is still at the development stage and is therefore receptive to external stimuli. To derive the maximum benefit from this temporary "receptiveness", it is advisable to put youngsters through separate and integrated co-ordination exercises (from 8 to 12 years of age). When they reach their growth spurt (11-14 years), they are faced with the phenomenon of physical change: their limbs will grow longer and their co-ordination will suffer as a result. At this age, therefore, co-ordination training is essential.

The ideal with young players is to do specific co-ordination and speed co-ordination training with fast footwork exercises (ladder drills, etc.) at least twice per week.

As a general rule, there need to be at least two or three 15 to 20-minute co-ordination training sessions each week. The warm-up phase is ideally suited to this.

It can be said that, from the age of between 8 to 9 up until the age of between 15 to 16, co-ordination forms an integral part of the training process, just as basic technique does, given that technical skills alone are not sufficient. Players have to work on sequences (e.g. sequences of moves), but also on different match situations that will stimulate the nervous system.

It is clear, then, that it is no longer in keeping with the modern game for players to have to learn their trade by means of static and isolated gestures. Movement, repositioning around the field and changes of direction have to be incorporated into all co-ordination and technical exercises.

Even though the nervous system's "thirst for learning" is much less developed in adults than it is in youngsters, it is still possible to improve the repertoire of motor and even technical skills. It has been proven that, by using running exercises, jumping exercises or also co-ordination exercises with a ball (concentrating on rhythm, differentiation and orientation), the range of a player's psychomotor abilities can be increased still further, even after the age of 25.

Co-ordination abilities can be improved with additional training exercises (e.g. playing other sports), or by integrated training sessions. As is the case with speed training, co-ordination training should not be performed when the players are in a state of fatigue, as the control and learning processes cannot operate to their full potential.

These exercises have to be repeated, drilled and gradually introduced into multiple-exercise sequences that work on all of the co-ordination skills required.

Co-ordination exercises therefore constitute an excellent preparation phase for technical and tactical/technical training.

It is not possible to train co-ordination skills in an optimum way unless they are combined with factors related to physical condition, namely speed, strength and endurance.

A highly talented and technically skilled player often has better developed co-ordinational skills than other players. If a player is able to control his movements well and possesses good co-ordination abilities, this will increase his confidence, which will, in turn, have a positive influence on the development of his personality.

→ **Co-ordination and technique are the key elements when training youngsters at the pre-development/pre-training stage.**

NB In Chapter 10 – **The Player of Tomorrow**, we shall be presenting various essential principles for the physical training and preparation of young players.

Examples of integrated exercises to develop co-ordination skills

Objectives	
Orientation **Differentiation** **Equilibrium**	• The player has his back to goal, receives and controls the ball on the turn before shooting into a predetermined area of the goal (emphasis on precision).
Orientation **Reaction** **Differentiation** **Equilibrium**	• Shooting accurately at a specific area of the goal (near or far post) after somersaulting on the ground and controlling the ball.
Balance + fast footwork **Rhythm** **Orientation** **Differentiation**	• Sequence of high-speed jumps landing on the right and left foot in circles placed on the ground, receiving the ball and doing a slalom around poles and making a long aerial pass.
Differentiation	• Juggling with a football, tennis ball, volleyball, etc.
Differentiation **Orientation**	• The same as above, but with the players doing a half-turn.
Rhythm **Balance + fast footwork**	• Running with the ball (using the inside and outside of the foot), slalom with two or three touches of the ball, etc. • The same as above, using the left and right foot.
Orientation **Differentiation** **Reaction** **Equilibrium**	• Trying to score from balls coming in either directly or indirectly at high speed, at different trajectories and from different distances (emphasis on timing).
Equilibrium **Orientation**	• Trying to score while being harassed and jostled by an opponent (one-on-one duel).