

## Chapter VII

# SPEED

Speed, like strength and endurance, is a conditional ability. It has a complex nature as it depends to a considerable extent on the central nervous system. Due to this fact the exact nature of speed abilities is difficult to discover and understand. Moreover, because we can influence the functioning of central nervous system only to a very limited extent, therefore, speed performances can not be improved to considerable extent as is the case in strength and endurance. Besides because of the high role of co-ordinative processes in a speed performance, the improvement of speed has to be done with specific means and methods.

Speed ability should not be equated with mechanical speed which is equal to the distance covered per unit of time. In several sports actions no distance is covered at all. Speed ability primarily signifies the ability to execute motor movements with high speed. These movements may be cyclic or acyclic in nature. Theiss and Schnabel (1987) give the following definition of speed:-

“It is the performance prerequisite to do motor actions under given conditions (movement task, external factors, individual prerequisites) in minimum of time”.

In spite of the complex and specific nature and low trainability speed ability is of high importance in all sports except endurance sports. Speed performances appear in different form in various sports. These have a different nature in cyclic sports as compared to acyclic sports.

From general point of view we can have five type of speed abilities : reaction ability, movement speed, acceleration ability, locomotor ability and speed endurance. Reaction ability in reality, is not a speed ability as it depends entirely on co-ordinative processes. It is a co-ordinative ability. But traditionally, it has been considered a speed ability and the training of reaction ability is, most of the time, inseparably linked with the training of movement speed. It is, therefore, being dealt with here along with the other speed abilities. Speed endurance is an endurance ability but training of speed endurance involves training of speed. Because of this reason it has also been included under speed abilities.

From the above discussion it becomes clear that there are only three speed abilities i.e., movement speed, acceleration ability and locomotor ability. Some experts also name movement frequency as a separate speed ability. But movement frequency by it self can not be given the status of a speed ability. In several sports, especially

cyclic sports, certain movements are repeatedly done at a high frequency but this frequency rarely reaches the maximum possible values. Movement frequency, therefore, should be understood as an important prerequisite for acceleration ability and locomotor ability.

A short explanation of the above mentioned five speed abilities is given below :-

### ✓ Reaction Ability

It is the ability to react effectively and quickly to a signal. In sports, signals can be of different type e.g., visual, tactile, acoustic. Depending on the degree of complexity of the reaction required the reaction ability can be further differentiated into simple and complex reaction ability.

### ✓ Movement Speed

It is the ability to do a single movement in minimum of time. Movement speed is of high relevance in acyclic sports. In cyclic sports it is important in the initial phase (e.g., start movement) or in some phases during the total period of cyclic activity e.g., turns in swimming and hurdle clearance in hurdle event. In acyclic sports movement speed is very closely bound with technique and tactical action. Depending on the nature of the movement the ability of movement speed depends on a different complex of factors in different sports. But it generally depends heavily on explosive strength and technique.

### ✓ Acceleration Ability

It is the ability to achieve high speed of locomotion from a stationary position or from a slow moving position. Acceleration ability depends to a great extent on explosive strength, technique and movement frequency. Performances in sprint events are determined to a great extent by acceleration ability. Acceleration ability is also of crucial importance in all team games and racket sports where high running speeds are to be achieved over short distances.

### Locomotor Ability

It is the ability to maintain maximum speed of locomotion for maximum possible duration or distance. Locomotor ability is important in only a few sports or events e.g., 100m and 200m in track and field, short sprints in track cycling and speed skating. In swimming, rowing etc., locomotor ability is not of much importance because all events last for more than 40 sec. On the other hand in these sports speed endurance is of high importance. Locomotor ability depends to a great extent on mobility of the nervous system which allows for high movement frequency. It further depends on technique, ability to relax and explosive strength. The trainability of locomotor ability is very low.

### Speed Endurance

It is the ability to do sports movements with high speed under conditions of fatigue. Speed endurance is a combination of speed and endurance abilities. It

is of a different nature in cyclic and noncyclic sports. In cyclic sports the speed endurance is required to continue movements with high speed in spite of the rapid accumulation of fatigue during the activity. In noncyclic sports the speed endurance is required to do movements again and again with maximum possible speed under conditions of fatigue e.g., repeated sprints in football. Speed endurance depends considerably on anaerobic capacity, technique and psychic factors.

### Factors Determining Speed

Speed abilities are trainable to a very limited extent due to its marked dependence on the functioning of the central nervous system. In practice, therefore, speed performances are commonly improved not directly by improving the functioning of central nervous system but indirectly by improving the various factors on which the speed performance depends. It is, therefore, of great practical importance to know the factors which determine speed performance. These factors are explained below:-

#### (A) Mobility of the Nervous System

During all speed performances the muscles have to contract and relax at maximal possible speed e.g., in sprints. This rapid contraction and relaxation of muscles is possible only if the concerned motor centres in the CNS can undergo rapid excitation and inhibition. This is called the mobility of the nervous system. When this rapid excitation and inhibition of motor centres takes place at maximal speed and for some seconds then the excitation process tends to spread to the neighbouring motor centres (irradiation) causing unnecessary tension in the body and thereby resulting in deterioration in speed performance. The mobility of the nervous system is trainable to a limited extent. It seems to be determined to a great extent by genetic factors.

When muscles contract and relax repeatedly in a definite sequence then the nervous system tends to adapt to this thereby resulting in 'speed barrier'.

#### (B) Explosive Strength

The speed performances depend to a great extent on explosive strength of the muscles concerned. This fact is especially vital for speed performances in which some resistance has to be tackled. Because of the importance of explosive strength and its high trainability most of the times speed performances are improved by improving explosive strength.

Explosive strength further depends on muscle composition, muscle size and muscle co-ordination (inter and intra-muscular co-ordination). It also depends on metabolic processes. Except muscle composition all other factors can be improved through training.

The relative proportion of fast twitch and slow twitch fibres determines to a great extent the maximum possible speed with which a muscle can contract. But this is not trainable as it is genetically determined. Good sprinters have a very high proportion of fast twitch fibres whereas endurance athletes have a very high

proportion of slow twitch fibres. According to Hartmann and Tunnemann (1986) sprinters have fast twitch fibres up to 90% in soleus muscle whereas long distance men have slow twitch fibres up to 90% in the same muscle. The muscle composition, however, is characterized by high inter muscular and individual differences.

### (C) Technique

Technique is an important factor determining speed performance. Unlearned movements cannot be done at high speed. This is particularly applicable to complex and difficult movements. Moreover, good technique enables the sportsman to fully utilise his strength, flexibility etc., to achieve high speed. The movement speed in gymnastics, combat sports etc., is highly dependent on technique or skill. Like explosive strength technique is also very commonly an aim of training for improving speed performance.

### (D) Bio-chemical Reserves and Metabolic Power

For maximal speed performance the muscles need high amount of energy at a very high rate of consumption. For this purpose the phosphogen stores in the muscles should be enough. Moreover, the metabolic process of energy production must take place at a very high pace. For this purpose sufficient amount of non-oxidative enzymes is essential. Acceleration ability, locomotor ability and speed endurance are particularly dependent on the bio-chemical reserves and metabolic power.

### (E) Flexibility

Flexibility includes the stretchability of the muscles and mobility of the joints. Good flexibility allows for optimum range of movement without much internal resistance, thereby positively affecting speed. Flexibility also enables full utilisation of explosive strength. Low flexibility leads to excessive internal resistance, muscle tension and less than optimum strength application.

### (F) Psychic Factors

Speed depends considerably on certain psychic factors. Important among these are optimum arousal and motivation, attention and concentration, ability to relax and the ability to maximally mobilise one self for a short duration. In addition to these factors the anticipation ability is of high importance for quick reactions.

The ability to relax the non contracting body parts and muscles has been found to be of high importance for speed performances especially acceleration, locomotor and speed endurance abilities. But unfortunately this ability seems to depend much on the central nervous system and as a consequence it cannot be significantly improved.

All the speed abilities do not depend to the same extent on the various factors mentioned above. Each speed ability is relatively independent of other speed abilities. In other words each speed ability depends on a different complex of the factors described above. As the improvement of speed abilities is most commonly

done by improving the factors on which it depends, therefore, a general view presented in a table below:-

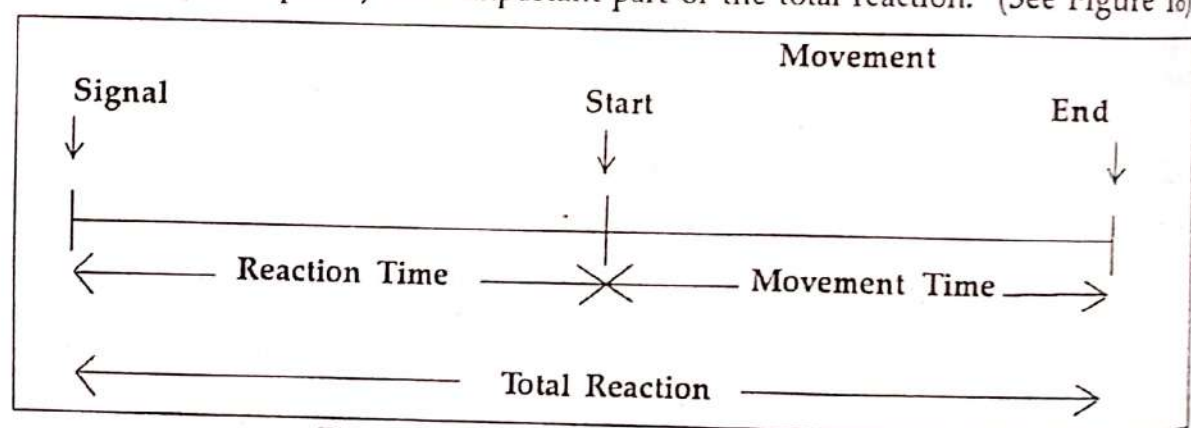
**Table 16**  
**Factors Determining Various Speed Abilities**

Speed ability	Important determining factors
Reaction ability	Functional capacity of sense organs e.g., eyes, ears etc., co-ordinative processes of CNS, selection and decision making, attention and concentration, anticipation.
Movement speed	Explosive strength, technique/co-ordination, metabolic power (alactacid), flexibility, attention and concentration.
Acceleration ability	Explosive strength, technique/co-ordination, mobility of CNS, metabolic power (alactacid), flexibility.
Locomotor ability	Mobility of CNS, technique/co-ordination, ability to relax, metabolic capacity and power (alactacid), explosive strength and flexibility.
Speed endurance	Anaerobic capacity (buffer capacity and lactic acid tolerance), explosive strength, technique/co-ordination.

**Improvement of Speed Abilities**

**I. Reaction Ability**

In sports reaction ability is required to react quickly and effectively to various signals and changing situations. Reaction time is a component of reaction ability which also includes the time of reaction or response. Hence, in sports the speed of movement (i.e, response) is an important part of the total reaction. (See Figure 18).



**Fig. 18 Phases of a reaction in Sports.**

Reaction time is most commonly taken as a measure of reaction ability. But it must be considered that reaction time does not include the reaction itself. It is the time interval between the signal and the start of the movement. In sports,

except in a few events like 100 m sprint, reaction ability cannot be judged simply by considering the reaction time. The speed and correctness of the reaction also has to be considered. But if other things are constant then reaction time assumes high importance for the judgement of reaction ability. Reaction time can be further broken into the following six parts (Singh 1984).

- (a) Time taken by the signal to reach the sense organs.
- (b) Time taken by the sense organ to generate a nerve impulse.
- (c) Time taken by the nerve impulse to reach the concerned centres in the CNS.
- (d) Time taken by CNS to generate a motor nerve impulse.
- (e) Time taken by the motor nerve impulse to reach the muscle.
- (f) Time taken by the muscle to begin the contraction (latent time).

Reaction ability can be divided into various types according to the type of signal or according to the nature of the response. According to the type of signal we can classify reactions into three types : visual reactions, acoustic reactions and tactile reactions. Tactile reactions are the fastest whereas the visual reactions are the slowest.

According to the nature of reaction the reaction ability can be divided into two types : simple reaction ability and complex reaction ability. Vilknor (1987), however, mentions three types of reaction abilities : simple, complex and selection reaction abilities. According to Vilknor simple reaction ability is involved when only part body movements are to be done on a signal whereas complex reaction ability involves the movement of whole body e.g., sprint start.

### Simple Reaction Ability

In simple reactions the signal and response are both known to the sportsman e.g., sprint start. Simple reaction ability is of importance in starts in swimming, cycling and track and field sprint events. In these sports the sportsman learns the reaction or movement as a skill and, therefore, reaction time is a reliable measure of simple reaction ability. Studies conducted on reactions to sound and light signals reveal some important facts.

- (a) Women have longer reaction time as compared to men.
- (b) In track and field reaction time increases with the distance to be run.
- (c) Elite sprinters have an average reaction time of about 0.12 sec.
- (d) Reaction time of different body parts is different. Arms are faster than legs and hands are faster than the arms.
- (e) Good sprinters are stable in reaction time performance.

- (f) Reactions are slower if the movement to be executed is complex or unlearned.
- (g) Emotions specially anger, fear have an 'inverted U' relationship with reaction time.

The methods for improvement of simple reaction ability are given below:-

#### (A) General Method

Playing different types of games in which quick reactions are frequently required is a general but effective method for improving simple reaction ability of children and beginners. It improves the reaction ability to a certain extent after which further improvement is possible through specific reaction exercises.

#### (B) Reacting Repeatedly on a Signal

In this method specific reaction exercises are done. The Sportsman reacts repeatedly and with maximal effort to a Signal e.g., sprint starts. The reaction exercises are arranged in series of 3-4 with full rest in between. To increase variation the nature of signal and response can be varied e.g., the tone and intensity of sound or light signal.

#### (C) Part Method

This method aims at improving the movement time and reaction separately. For the improvement of movement time the factors on which it depends are improved e.g., technique, explosive strength. Reaction time is, however, improved through reaction exercises.

#### (D) Sensory Method

This method was first explained by Zaciorskij in 1971. Since then this method has been suggested by other experts also e.g, Martin (1979), Matweyew (1981) and Singh (1984). The sensory method is based on the assumption that reaction ability is very intimately linked with the ability to differentiate time intervals. The application of the method is done in stages described below:-

1. The sportsman reacts (e.g., 10m.sprint) with maximum speed on a signal. After each reaction he is told the time taken for the exercise.
2. The sportsman reacts repeatedly to a signal but with increasing speed. After the reaction he is asked to tell the time he has taken for the exercise. The time keeper or the coach then tells him the actual time he has taken. In this way his subjective judgement of time differentiation is improved.
3. The sportsman reacts repeatedly to a signal but with different speeds. His subjective assessment of time is continuously compared with the time taken by a timing device.

The sensory method should be used after the other methods have been exhausted.

### Complex Reaction Ability

Complex reaction ability is needed when there is uncertainty about the signal or response or both. This is the case in team games and combat sports. The sportsman does not know on which signal he should react and in what manner. The time of occurrence of signal also may not be certain. Complex reaction ability is partly dependent on the simple reaction ability. It also depends to a great extent on two factors which have to be improved to improve complex reaction ability. These factors are : anticipation of the signal and quick selection of correct response. Complex reaction ability, therefore, involves selection and decision making processes. The possibilities of improvement of these two factors is discussed below:-

#### A. Anticipation

For quick and correct reaction the sportsman should be able to correctly anticipate the movement or action of the opponent. This should be timely in order to allow for a correct and quick response. Sportsman should be trained for good anticipation as in tactical sports the opponent tries to conceal his intention/movement in order to lead the sportsman to wrong anticipation. The ability to anticipate depends primarily on three things explained below:-

##### 1. Movement Structure

Knowledge of movement structure can help the sportsman to anticipate the movement by correctly judging the preparatory phase movements of an action. The sportsman, however, should not be hasty in reaching a conclusion because preparatory movements can form part and parcel of a fake movement. Moreover, the sportsman should also always keep in mind the probability of occurrence of a movement e.g., in boxing and wrestling when a sportsman is in a certain position then only few limited number of movements are possible.

##### 2. Tactical Pattern

All sportsmen, to a limited or greater extent, form the habit of doing only certain definite movements when they are in a definite situation. A knowledge of this helps the sportsman to anticipate the actions of an opponent. The observation and study of these patterns, as a principle, should form part and parcel of tactical preparation for obvious reasons.

##### 3. Experience

For good anticipation there is no substitute for experience. Therefore, sportsmen must participate in many competitions and should face different opponents and situations.

#### B. Selection of Correct Response

This involves the process of selection. This depends on the ability of the sportsman to decide which will be the best response. In order to save time and to



respond quickly it is better to link certain signals with certain responses. This can be done by devising appropriate drills and letting the sportsman practise these again and again. These drills, however, should not be highly automatised otherwise the sportsman is unable to change the response if the situation so demands.

Quick selection of correct response depends to a great extent on the experience of the sportsman. In addition, it is also determined by quick thinking, correct perception of the situation, emotional control and creativeness.

## II Acceleration Ability

Acceleration ability, like all other speed abilities, can be improved directly or indirectly. It is improved indirectly by improving explosive strength, technique, flexibility etc.

For the direct improvement of acceleration ability short sprints are the best means. The distance or duration of these sprints is based on practical experience as well as on some research findings. Henry (1952) found that sprinters achieve their maximum speed in about 6 seconds after the stationary start. Farfel (1952), Zdanov (1956) and Furnadziev and Petkova (1977) also found that irrespective of the performance level and age the maximum speed is achieved in 5-6 sec., after the start. They also found that during a sprint the increase in speed is as follows:-

At the end of

1st sec	- 55%
2nd sec	- 76%
3rd sec	- 91%
4th sec	- 95%
5th sec	- 99%

Harre (1986), however, states that the duration for achieving maximum speed is lesser in case of lower level sprinters. Teichgrabber (1982) also suggests shorter durations for children and lower level sprinters. Jung (1982) found that in 80m sprint men achieved maximum speed at about 45m whereas women achieved it at about 25m.

For improving acceleration ability the following load parameters are suggested:-

- Intensity - Maximum or near maximum.
- Duration - The duration of the sprint should be from 4-6 sec. It can be less for children.
- Distance - In view of the duration the distance will differ from activity to activity. It will also depend on the nature of sport.

- Repetitions - According to the training state. These should be arranged in series of 3-4 repetitions. The sprints should be stopped when the time of sprints starts decreasing.
- Recovery - Full recovery in between the series. Duration of recovery will depend on the duration or distance of sprints. Active recovery is advisable. In case of long recovery periods exceeding 5 min. a short warm up before the commencement of next series is needed.

### III Locomotor Ability

It is the ability to maintain maximum speed of locomotion for maximum duration possible. According to Gundlach (1969) the speed ranges from 99-100% of maximum during the phase of maximum locomotion speed. He found that in track and field sprints it can last from 20-45 m. But this phase of maintenance of maximum speed is different for different persons depending on their age and performance level. Gundlach (1969), Furnadziev and Petkova (1977) and Letzelter (1975 and 1978) found the distance over which maximum speed can be maintained as follows:-

12-13 year old children	-	15-20m.
14-16 year old children	-	20-30m.
12-13 year old trained children	-	20-30m.
Well trained adults	-	30m and longer.

For the improvement of locomotor ability sprints are used. But the duration/distance of the sprint must allow for full acceleration followed by desirable duration/distance for maintenance of maximum speed. The following load parameters are suggested for the improvement of locomotor ability:-

- Intensity - Maximum or near maximum.
- Duration - 6-9 sec
- Distance - Will differ from sport to sport according to the suggested duration of sprint.
- Repetitions - 5-10. In case the distances are shorter these can be arranged in series of 2-3 repetitions. Training should be stopped when the sportsman starts getting tired.

**Recovery**

Full recovery. Nature of recovery should be active. In case recovery period is longer than 5 min., then a short warm up is required for the start of next repetition or serie.

The locomotor ability depends heavily on the mobility of the CNS and on the ability of the sportsman to relax his non involved body parts and muscles during the phase of maximum speed. Hence sprints for locomotor ability must be done with conscious effort to achieve relaxation during the sprint.

As it is mostly difficult to improve locomotor ability, therefore, much stress should be laid on the improvement of those factors which determine locomotor ability. All these factors are not significantly trainable e.g., mobility of the CNS and relaxation ability. But technique, explosive strength etc., are trainable to a high degree.

**IV. Movement Speed**

Movement speed is of importance in acyclic events and sports e.g., throws, gymnastics, combat sports etc. In these sports the movement speed is very closely linked with technique and tactics of the sports. Depending upon the nature of speed it further depends heavily on explosive strength, flexibility, co-ordinative abilities, attention etc. Movement speed is most frequently improved indirectly by improving technique, explosive strength and other determining factors. This indirect method has proved to be very effective. But sometimes, especially during the competition period the movement speed has to be improved directly and for this purpose the specific movement is practised in the following three manners:-

**A. Repeating the Movement with Maximum Speed**

The concerned movement is executed again and again with maximum speed. It is important to take the time taken to complete the movement as feedback is very important for improving movement speed. In some sports the concerned movement can be done several times without pause e.g., in boxing. In such cases the time of total repetitions should be taken.

**B. Practising the Movement under easier Conditions**

The movement is executed at maximum possible speed under conditions which enable higher speed. For example this can be achieved in the following manners:-

- (a) By reducing the resistance e.g, in shotput.
- (b) By doing the movement on a faster surface.
- (c) By using external help e.g., use of jump boards etc.

When making the conditions easier care should be taken to ensure proper movement structure. Too easy movement execution may prove harmful for the motor co-ordination required for the movement. It is also advisable to meaningfully combine the movement practice under easier and normal conditions in a training session.

### C. Practising with a Faster Rhythm

Each movement has its own rhythm. If during the movement execution a slightly faster rhythm is given from outside the sportsman is able to do the movement faster. The rhythm to be given should correspond to the actual rhythm of the movement and should be properly given otherwise it will tend to slow the sportsman and will also have a negative effect on motor co-ordination.

The training for movement speed requires a high degree of concentration and attention. This should always be ensured for best results. The training should also ensure correct movement execution. In order to achieve high speed the sportsman tends to do the movement incorrectly. Hence a constant and effective check is required in this regard.

The training for movement speed should be done by using the specific movement. During practise the other normal requirements on the movement during competition should also be ensured for best results. The load factors for improving movement speed are given below:-

- |             |   |   |
|-------------|---|---|
| Intensity   | - | Maximum to near maximum but with correct movement execution and high degree of attention and concentration.   |
| Repetitions | - | Many. Preferably arranged in series of 4-5 repetitions.   |
| Recovery    | - | Complete and active. In case of longer recovery periods a short warmup before the next series is required. Because of high demands on co-ordination, concentration etc., recovery period should be interesting in nature with a change of activity. |

### V. Speed Endurance

Speed endurance can be improved significantly through training. For its improvement both indirect and direct methods should be used as both are effective methods. In indirect method effort should be made to improve anaerobic capacity (especially lactic acid tolerance), explosive strength and technique.

Harre (1986) stresses the importance of basic endurance training for speed endurance. He is of the opinion that the amount of basic endurance training in speed endurance sports should be quite high upto 90% of the total training volume in the preparatory period.

The methods for the improvement of speed endurance are described below:-

### A. Repetition Method

This method when used with specific movement can be highly effective for improving speed endurance but for its success a good level of basic endurance is a necessary prerequisite. Harre (1986) suggests two variations of this method which can be effective for cyclic sports.

1. Repetitions with high speed over distances which are 2/3 to double of competition distance e.g., tempo runs up to 300 m in track and field.
2. Repetitions with maximum speed over distances which are 10-20% longer than the competition distance.

In the above mentioned two variations required number of repetitions are done with complete recovery in between the repetitions. When the repetitions are done with maximal or near maximal speed then considerably long recovery periods are needed. But if the speed is low then shorter recovery periods are needed and the repetitions can be arranged in series of 2-4 repetitions.

### B. Intensive Interval Method

This method is more suitable for the improvement of speed endurance in team games, combat sports and racket sports. In this method cyclic movements like running, cycling etc., can be used or specific movements of a sport can be used. The exercise is done at maximum or near maximum speed for a short distance or duration after which there is incomplete recovery of short duration. The load and recovery phase can also be determined according to the typical competition load structure of a sport. A typical example for speed endurance for hockey and football involving running is given below:-

Intensity	- Very high to maximum.
Distance	- 40-60 m.
Repetitions	- 3-4 series of 4-5 repetitions.
Recovery	- 20-30 sec., between repetitions, 3-5 min. between series.

In combat sports like wrestling, boxing and judo special circuits of 4-8 special exercises can be made and done according to intensive interval method for the improvement of speed endurance.