Strength-Speed Profile of Senegalese 400m Runners: Analysis via My Sprint

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***Abstract*- The aim of the study was to assess the strength-speed profile of Senegalese 400-metre runnerswho qualified for the national championships. Using the My Sprint test on a sample of 18 athletes, various measures such as maximum speed, theoretical maximum strength and maximum power were assessed. The results reveal an imbalance in the strength-speed profile of the athletes, with strength values significantly lower than those for speed. This disparity is attributed to training that favours speed over strength. To improve the performance of 400 metrerunners, it is crucial to balance these two parameters, as a more balanced profile between strength and speed is associated with better performance. Particular attention should therefore be paid to strengthening the strength component to optimise the performance of athletes in thisdiscipline.**

***Keywords*: profiling, speed, power, 400meter run.**

I- INTRODUCTION

Athletics is the first Olympic discipline. It is defined as all individual sports including running, jumping and throwing [Larousse Bordas-1997, first edition].

However, of all athletic activities, sprint races are the most widely practised, including the 400m. Still known as a long sprint, the 400 m race is considered to be an endurance speed, in that it requires, in addition to physical power, the ability to resist fatigue and pain, as well as optimal management of race frequency.

A race like the 400 metres is one of the most demanding events and requires very specialattention. Athletes have to concentrate on the pace of the race and manage the build-up of lactic acid that would enable them to finish in the best possible condition, hence the need for a good distribution of effort between the first and second 200 metres. Previous studies have shown that Senegalese athletes have the required physical qualities or are generally endowed with the physical potential to perform well in long-distance races.

Senegal has always excelled in the 400m race, as in the case of Amadou GACKOU, finalist at the 1968 Olympic Games in Mexico City with a time of 45.01, and Amy Mbacké THIAM, gold medallist in Edmonton in 2001 and bronze medallist in Paris in 2003. However, an analysis of the results obtained by Senegalese 400m runners in recentyears shows that they are no longer able to clock at least 46 seconds. They are almost never able to qualify for the finals at African and world competitions. Amadou Gackou'srecord, which dates back to 1968, has still not been beaten. This once again demonstrates the low level of Senegalese 400m flat racing in recent years compared with African and world performances.

So, in the light of these observations, we have tried to evaluate the strength-speed profileto develop power performance, and then seek to balance these two parameters.

We are also seeking to determine which of these two parameters needs to be improved in order to optimise the maximum power output of these devices of these athletes? What is at the root of the imbalance observed between these two parameters? What would be the best way to reduce this imbalance?

In order to respond to the established problem, we started from the hypothesis that speedis much higher than strength in terms of power in 400m runners in Senegal. Strength is therefore the parameter that must be improved in order to increase the athletes' maximumpower.

In fact, a significant difference will be observed in the evaluation of these two parameters.The general aim of this study is to provide coaches with guidance on how to train 400 mrunners to improve their performance effectively. From a specific point of view, the objectives of the research are: to reduce the imbalance observed between the two parameters: force (F) and speed (v). By comparing the results obtained for these two parameters, we will be able to give some suggestions for improving the maximum powerof 400m runners, in order to optimise their performance.

The study is divided into three main chapters:

According to LE GUARDER (1990) [1], speed is the physical quality that enables amovement to be performed very quickly or a large number of movements to be repeatedin a given time. Speed is the ability to perform motor actions in a minimum amount of time. For Pradet (1993) [2], speed can be defined as the ability to perform motor actions in a minimum amount of time over a short period of time, without taking into account the notion of fatigue. It can be divided into three forms:

- Reaction speed is an athlete's ability to perceive, analyse and process the signaltriggering an action in the shortest possible time.
- Gestural speed is the motor expression of action.
- Speed endurance corresponds to the need to repeat short, but intense or very intenseefforts over the entire match. It is the ability to maintain the maximum speed acquiredor coordinated fast actions (technical performance) for as long as possible, while resisting fatigue.
- Gesture frequency or movement frequency corresponds to the number of movementsperformed per unit of time. It corresponds to a number of movements performed in a given time.

According to Lagarder (1990) [3], strength is the capacity of the muscle to produce tension, i.e. to overcome or oppose resistance. It can be defined as the ability to overcome or resistexternal resistance through muscular effort. According to FOX. MATTHEWS (1984) [4], "muscular strength is defined as the tension that a muscle or group of muscles can exert against resistance at a single maximal effort". From a physiological point of view, it is characterised by the tension developed by the muscles following excitation. Muscular force is therefore the tension exerted by the muscle to mobilise or immobilise a joint.

From a muscular point of view, the force is exerted in several ways: isometric, when thecontraction does not cause any displacement of the bony levers; concentric, when the muscle shortens during a contraction; eccentric, when the muscle lengthens during its contraction, i.e. the two muscular insertions move away from each other. The plyometricregime, which combines the two previous regimes and is exercised when a muscle stretchin the eccentric regime is followed by a concentric contraction with no intermediate stopping time. There are different types of strength: maximum strength, speed-strength and endurance-strength. According to FOX AND MATHEWS (1984), dynamic maximalforce is the greatest force that the neuromuscular system can achieve by voluntary contraction during movement development. Speed-force (or explosive force) is defined as the capacity of the neuromuscular system to overcome resistance with the greatest possible speed of contraction (FOX AND MATHEWS, 1984). Endurance-force is,according to FOX AND MATHEWS (1984) [4], the body's capacity to resist fatigue duringlong-duration strength performance.

According to Bouchard, Brunelle and Godbout (1973) [1], muscular power is that quality which enables the muscle or muscle group to produce complex physical work. Power is the ability to express motor actions with maximum intensity (Hubiche and Pradet 1993) [2].Power is defined as the ability to produce maximum force as quickly as possible. It reflects the explosive aspect of strength.

II- METHODOLOGY

II. 1. Equipment

The study was carried out as part of a master's thesis and took place in Dakar, at the Abdoulaye WADE annex stadium in Diamniadio. This stadium, named after the former President of the Republic of Senegal, is located in Dakar (Diamniadio) and has a capacity of 2,000. It includes a football pitch and an athletics track with 8 lanes.

II-1-1. Study population

The population studied was made up exclusively of athletes specialising in the 400-metre race,competing at senior level and taking part in Senegal's national championships.

II.1.2. Sampling

The study sample consisted of 18 athletes specialising in the 400-metre race, distributed amongdifferent clubs as follows: Asfa (2), Jaraaf (3), us Gorée (2), Duc (3), as Douane (8)

Participants were selected according to the following criteria: Inclusion criteria:

- Qualify for the national championships.
- Reside in Senegal and regularly take part in competitions organised by the Senegalese Athletics Federation (FSA).
- Be aged between 18 and 35.Exclusion criteria :
- Not be qualified for the national championships.
- Developing outside Senegal.
- Be under the age of 18 (considered as not having reached senior age) or over 35.
- Being a 400-metre runner

II.2. Measuring instrument we used:

- an athletics track with a 30m zone;
- two (2) studs to mark the 30 m start and finish lines;
- Six cones and six stakes ;
- a 30m decameter;
- a scale graduated in kilograms to measure the weight of the subjects;

- a measuring rod graduated in centimetres to measure the standing height of the subjects ;
- an iPhone XR to take videos;
- a Vanguard tripod;
- registration forms (see appendix);

II.3. Methods

Our study protocol consists of two phases: Phase 1: measuring weight and heightPhase 2: the physical test

II.3.1. Weight measurement

The weight of an individual or object is measured using a balance. To obtain an accurate measurement, the subject must remove his or her shoes, stand facing horizontally with his or her arms at his or her sides. The weight is then read off the scale and expressed in kilograms (kg). This measurement is also used to calculate the Body Mass Index (BMI), which is calculated by dividing the weight in kilograms by the square of the height in centimetres (kg/m²).

II.3.2. Waist measurement

Height is the distance between the bottom of the feet and the top of the head. It is measured using a metal device graduated in centimetres (cm) called a somatometer. To measure it, the subject, barefoot, stands upright with his feet together, arms at his side and his gaze horizontal. The cursor of the somatometer is lowered until it touches the subject's head. Then read the scale indicated by the cursor

II.3.3. The physical test

The physical test was carried out using an application called My Sprint. This application was developed by a scientist by the name of Pedro Jiménez-Reyes.

My Sprint provides essential data on our athlete. It can be used to calculate the force- velocity (F-V) profile, and also to find out exactly what the athlete's sprint time was over5, then 10, then 15, then 20, then 30m, using radar. With or without additional load.

II.3.4. Setting up the race protocol

On the track, a 30-metre zone was marked out, with markers positioned at specific distances tocounteract the parallax caused by the iPhone's fixed location on a tripod 10 metres from the sprint lane. The markers were set at 5.57 metres, 10.28 metres, 15 metres, 19.72 metres, 24.43metres and 29.15 metres. The athletes' runs were filmed from start to finish of the 30 metres using an iPhone XR and the My Sprint application to analyse the performances and obtain the variables required for the study (Maximum Speed, Maximum Strength, etc.). The test took placeover the course of one day, from 4pm to 6pm, with the 18 athletes asked not to exert themselvesprior to the test and to carry out an adequate warm-up 30 minutes before the start of the eventsto prepare their bodies.

III- RESULTS

Table 1: Characteristics of subjects

Subject n=18	Performance	Age	Weight	Size
Total	901,29	406	1262,6	3244
Average	50,07	22,56	70,14	180,22
Standarddeviation	±1,78	±3,03	±7,43	±6,45

Analysis of the data provided reveals a number of interesting facts about the athletes' performance, age, weight and height.

Performance: Performances ranged from 46.61 to 53.57 seconds, with a mean of 50.07 secondsand a standard deviation of ±1.78, indicating relatively little dispersion of performance aroundthe mean. This suggests a degree of consistency in the athletes' performances.

Age: The average age of the athletes is 22.56, with a range from 19 to 28. The standard deviationof ±3.03 indicates a certain diversity in age, but within a range conducive to optimum performance based on examples of successful international runners in this age bracket.

Weight: The average weight was 70.14 kg, with significant variability ranging from 59.2 kg to 86.4 kg. The standard deviation of ±7.43 suggests a wider spread of athlete weights. The majority of athletes are below average, which may have implications for their ability to generatepower during sprints.

Height: The average height is 180.22 cm, with a range from 171 cm to 190 cm. The standard deviation of ±6.45 indicates relatively little variation in athlete heights. Although height may play a role in performance, it does not appear to be a major determinant according to these data.In conclusion, the athletes' performances are consistent with relatively small deviations from the averages. Age, weight and height may play a role in performance, but other factors such astraining and experience may also be determinants. A more in-depth analysis, taking these othervariables into account, could provide a more precise understanding of the determinants of performance in the 400 metre race.

Table 2: Speed of 400m runners

Subject N=18	Maximum speed (m/s)	V(0)
Total	158,56	163,66
Average	8,81	9,09
Standard deviation	±0,51	±0,61

Analysis of the data highlights significant aspects of the speed of 400m runners. Performance is assessed in terms of each athlete's maximum speed and initial speed (V(0)). Looking at the figures, we see that Athlete 18 has the highest maximum speed at 10.35 m/s, while Athlete 8 has the lowest maximum speed at 8.20 m/s. This significant difference suggests that Athlete 18dominates in terms of maximum speed.

Maximum speed plays a crucial role in an athlete's overall performance, particularly in disciplines such as sprinting where rapid acceleration is crucial. In the 400m, maintaining this maximum speed until the end of the race is also essential for success.

The initial speed (V(0)) varied from 8.42 m/s to 8.98 m/s, with Athlete 18 recording an exceptionally high value of 11.072 m/s. This suggests a powerful start for this athlete, which may have a positive influence on his performance.

At the aggregate level, the athletes' maximum and initial speed totals show a slight difference,with an average of 8.81 m/s for the maximum speed and 9.09 m/s for the initial speed. This difference can be attributed to extreme values such as that of Athlete 18.

The standard deviation reveals some variation in the runners' performances, with ±0.51 m/s formaximum speed and ±0.61 m/s for initial speed. This indicates a dispersion of the data aroundthe mean, although slightly less pronounced for maximum speed.

In conclusion, the balance between maximum speed and initial speed is crucial for a 400m runner. A high maximum speed enables rapid acceleration, while a solid initial speed guaranteesthe endurance needed to maintain performance over the entire distance. By working on these two aspects, runners can optimise their 400m performance.

Table 3: Maximum strength of 400m runners

Subject N=18	Max. force (N/)	Max force (N/Kg)
Total	15164,87	214,70
Average	842,49	11,93
Standard deviation	±345,23	±4,48

Examination of the measurements of maximum force in Newtons reveals important informationabout the physical capabilities of the 400m runners. Athlete 3 stands out with an exceptionallyhigh value of 1839.972 N, while the lowest values are observed in athlete 18 with 370.283 N and athlete 13 with 498.173 N. This suggests significant differences in force levels between athletes, with the highest performances generally associated with faster times on the track.

Looking at the relative maximum force in Newtons per kilogram, athlete 3 maintains a dominant position with 22.168 N/kg, indicating an exceptional ability to generate force per unitof body weight. In contrast, athlete 18 has the lowest value at 5.143 N/kg, suggesting a relativelylow level of force given his body mass.

The average of the maximum forces in Newton was around 842.49 N, indicating a reasonable ability to generate force among the athletes. However, the standard deviation of ±345.23 N reveals a wide spread of results, highlighting the variability of force levels within the group.

In terms of relative maximum force in Newtons per kilogram, the average is around 11.93 N/kg.This value represents the average capacity of athletes to generate force per kilogram of body weight. However, the standard deviation of ±4.48 N/kg also highlights a significant dispersionof results around this average.

In conclusion, the data indicate significant variations in maximum strength levels between 400m runners. Maximum strength, whether absolute or relative to body weight, plays a crucialrole in track performance, alongside other factors such as power, endurance and technique. Therefore, training to improve maximal strength can contribute to optimal 400m performance.

Table 4: Power of 400m runners

Subject N=18	Max power (W)	Max power (W/Kg)
Total	34161,24	484,91
Average	1897,85	26,94
Standard deviation	±745,62	±9,55

The data provided relates to the maximum power in watts (W) and the maximum power in watts per kilogram (W/kg) of eighteen different athletes. Let's take a closer look at these results.

Firstly, in terms of maximum power in watts, athlete 3 stands out with an impressive value of 4018.847 W, while the lowest values are observed in athlete 18 with 1024.92 Wand athlete 13 with 1062.688 W. These data highlight the significant differences in powerlevels between athletes, which is crucial in many sports for achieving top-level performance.

Next, let's look at the measurements of maximum power in watts per kilogram. Once again, athlete 3 has the highest value at 48.42 W/kg, indicating high power per unit weight. By contrast, athlete 18 has the lowest value at 14.235 W/kg, indicating relativelylow power for his body mass.

The average maximum power in watts was around 1897.85 W, suggesting a reasonable ability to generate maximum power among the athletes. However, the standard deviationof ±745.62 W reveals a wide dispersion of results, highlighting substantial variability in performance.

In terms of maximum power in watts per kilogram, the average is around 26.94 W/kg. This value represents the average power that athletes are capable of generating per kilogram of body weight. However, the standard deviation of ±9.55 W/kg also indicatesa significant dispersion of results around this average.

In conclusion, the data provided reveals a significant variation in maximum power levelsbetween athletes. Some perform exceptionally well in terms of power, while others havelower scores. The mean values indicate a reasonable amount of power developed on average, but the standard deviation shows a scattering of results, highlighting the heterogeneity of the performances of the athletes studied.

Table 5: 10m force ration and peak force ratio

Subject N=18	10m force ratio	Peak force ratio (%)
Total	5,88	1095
Average	0,33	60,83
Standard deviation	±0,02	±7,68

The results provided concern the force ratio at 10 metres and the peak force ratio as a percentagefor eighteen different athletes. Let's analyse the data in detail.

Firstly, with regard to the force ratio at 10 metres, the maximum value was 0.348, obtained byathlete 5, while the minimum value was 0.287, obtained by athlete 3. These results indicate relatively little variation between athletes, with force ratios mainly between 0.287 and 0.348. This analysis suggests that athletes 1, 2 and 3 produced the greatest forces over the first 10 metres of the race, which can be attributed to their explosiveness and ability to produce optimalspeed.

Next, let's look at the measurements of the peak force ratio as a percentage. The maximum value of 72% is shared by athletes 1, 2 and 3, while the minimum value is 41%, obtained by athlete 18. This greater variation between athletes suggests a significant difference in their ability to achieve a high proportion of their theoretical peak strength. This analysis highlights

the importance of initial strength in overall performance, with some athletes being closer to their maximum strength limit than others.

With regard to the averages, the force ratio at 10 metres is approximately 0.33, with a standarddeviation of ±0.02, indicating a relatively low dispersion of the results around this average. Forthe peak force ratio as a percentage, the mean is around 60.83%, with a standard deviation of ±7.68%, showing a greater dispersion of results.

In conclusion, the data provided reveals a relatively homogeneous level of force ratio at 10 metres, with little significant variation between athletes. On the other hand, the peak force ratioas a percentage shows greater variation between athletes, highlighting a significant difference in their ability to use their maximum force. The mean of the two measures indicates moderate performance, but the standard deviation highlights a significant dispersion in the results, indicating significant variability in performance among the athletes studied.

Table 6: Force speed of 400m runners

Subject N=18	Force-speed
Total	-1687,35
Average	-93,74
Standard deviation	±40,17

The results provided concern the strength-speed of eighteen different athletes.

All the force-velocity measurements are negative, suggesting resistance or a decrease in speedrather than an increase. The absolute values of the results indicate the intensity of this resistance or decrease.

The absolute maximum value is 210.601, obtained by athlete 3, which suggests a strong resistance or decrease in speed in this athlete. The absolute minimum value is 33.444, obtainedby athlete 18, indicating a relatively low resistance or decrease in this athlete. It should be noted that increasing speed has a counter-effect on the maximum force produced. In other words, the faster the muscle contracts, the less force it is able to produce and vice versa, whichis characterised

by the force-velocity relationship. This FV relationship is a representation ofthe maximum force an individual is capable of producing against different loads as a functionof the speed of muscle contraction achieved during the movement.
The average force-velocity is approximately -93.74, showing a moderate resistance or decrease in speed on average in the athletes. However, the standard deviation of ±40.17 indicates a wide dispersion of results around this mean, highlighting significant variability inindividual responses.
In conclusion, according to our analysis, athletes 1, 2 and 3 have a much higher strength- speed capacity than the others, but this does not prevent them from having an unbalanced profile due to the differences observed between the athletes' averages in terms of relative maximum strength (F0) and initial speed (V(0)). Such an imbalance can be attributed to much higher speed training than strength training. It is important to recognise that the best way to improve power performance is to know the strength-speed profile of athletes and toseek to develop it. Continuous monitoring at different periods in their development enablesthe athlete's progress in this area to be assessed.

CONCLUSION

The aim of our study was to assess the strength-velocity profile of 400-metre runners whotook part in the Senegalese national championships. To do this, we used the MySprint test,which evaluates several parameters such as maximum speed (VMax), theoretical horizontalmaximum force (F0 in N), relative theoretical horizontal maximum force (F0 in N/kg), theoretical initial speed (V0), maximum power (PMax in W), relative maximum power (PMax in W/kg), force-velocity (FV), force ratio over 10 metres (RF_10m) and maximumforce ratio (RF Peak).
Analysis of the results shows that our athletes' performances are generally acceptable. However, there were significant differences between the averages of our 400m runners, particularly in terms of strength and speed. The speed values are clearly higher than thosefor strength, indicating a deficit in strength relative to speed in our athletes, resulting in unbalanced strength-speed profiles.
It follows that the development of maximum power (PMax) in our 400 metre runners should involve improving strength, which lags behind speed. Thus, training aimed at strengthening the strength component could be beneficial for balancing the strength-speedprofile of our athletes and improving their overall performance on the track.

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