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Physical Analysis

of the FIFA Women's World Cup Germany 2011™





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Foreword



Without doubt, the sixth FIFA Women's World Cup™ marked an important chapter in the history of women's football. The 16 teams that participated in Germany confirmed that women's football is continuing to grow and develop, and that the game has reached a high standard.

No matter what level it is played at, football requires thorough, supervised physical preparation. At international competitions like the World Cup, only teams with excellent physiological qualities, in optimum athletic condition and that are extremely well prepared physically will reach the semi-finals.

FIFA has always attached great importance to health, as it is an essential element of football and its development, and over the last few years, a number of programmes have been elaborated in this area at FIFA. The 11 for Health is based around simple messages presented by well-known professional footballers to encourage people to play football, protect themselves from injuries and diseases and live a healthy life. The FIFA 11+ warm-up programme, meanwhile, has been proven to reduce the risk of serious injury in women's football by almost half if practised regularly.

FIFA is very pleased to share with you the results of this first specific study analysing the physical performance of the teams at the FIFA Women's World Cup Germany 2011™.

Joseph S. Blatter
FIFA President

Preamble

Following the spectacular action at the sixth FIFA Women's World Cup™ in Germany in 2011, it is fair to say that women's football is continuing to grow and develop. The immense efforts of FIFA and several countries to develop the game in all six confederations have well and truly borne fruit, not only because the game has become more and more popular with women, but also because the quality of the game has improved, as proven by the vast majority of teams in FIFA's flagship women's competition for the best teams in the world.

After this Women's World Cup, all of the experts are in agreement that huge progress has been made in recent years, whether in terms of the level of play, attacking and defensive moves, or the technical skill of many teams' players with the ball at their feet, as well as the great cognitive qualities (game intelligence and individual tactics) of the players, and most notably of the most experienced players. Other key findings were the fighting spirit on show and many teams' determination to attack, as well as the players' sense of fair play.

Nevertheless, this progress in the game, which is often coupled with high speed and the players' total commitment – most notably in the cases of the USA, Japan, France, Sweden and England – could not have been made without good physical preparation, great psychological qualities and the perfect athletic base.

This year FIFA, keen to draw even more attention to the main physical capacities and their influence on team play and the individual play of players, is happy to present, along with the technical report, the very first dedicated study into the general physical performance of teams at the FIFA Women's World Cup.

To create a coherent, comprehensible study for all readers, the analysis has been broken down into three areas:

1. to draw more attention to physical performances in a women's football match, particularly by presenting the distances covered and by comparing the teams that participated in this World Cup;
2. to analyse the distances covered by players on the basis of individual results and results by position in order to enable coaches to adapt their training sessions and their methods to the reality of a match;
3. finally, as a conclusion from all of the data presented, we make some proposals and some methodological recommendations for training.

This study does not seek to compare women's physical performances with those of men. However, certain data is presented without being compared or analysed to help the coaches understand the data better.

Since the 1990s, various studies have been conducted into women's football as well as men's football. We know that the average total distance run by position is 10.3km, including 1.6km at high speed (i.e. between 18km/h and 25km/h). We also know the different speeds of running, the distances run in sprints and at what speed, and the influence of the energy sources (aerobic and anaerobic, alactic and lactic) on the body. Unfortunately, these studies are not very well known by the vast majority of coaches, and especially not by the general public.

On the basis of these facts, but also as part of one of FIFA President Joseph S. Blatter's main objectives, to continue



to develop women's football and to improve coaches' knowledge of the game, FIFA is proud to present this dedicated physical report in eight different analysis areas:

1. Analysis of the height of players and of the average duration of matches with the actual playing time
2. Analysis of the total overall distances covered in a match and in each half with a comparison of the performances of the various teams, most notably of the teams eliminated at the end of the group stage and of the teams that qualified for the knock-out stages
3. Analysis of sprints (maximum and optimum) and of high-speed runs with a correlation between the speed and the number of goals scored
4. Analysis of distances covered with and without the ball
5. Analysis of total overall distances covered in different positions
6. Analysis and comparison of the distances covered by seven top-class 2011 "FIFA all-star" players
7. Analysis of the final between Japan and the USA
8. Consequences of these analyses and specific training recommendations to improve physical fitness levels in women's football

This study does not attempt to be scientific; it is meant to be primarily methodological by presenting complete and practical analyses for all readers.

Nevertheless, to make it possible to draw some comparisons and to back up our arguments, we have referred to some scientific studies that have been conducted in men's and women's football over the course of the past decade.



Methodology

The physical performance data in terms of how far each team ran was collected from the 32 matches of the FIFA Women's World Cup Germany 2011™ and from all of the players in each match. In total, more than 400 players were observed and analysed during this study. The total distances covered were calculated from the outfield players who played the whole match, without taking

the goalkeepers into account. Only the sprint distances (maximum and optimum) covered by the goalkeepers were taken into account.

All of the analyses were conducted over the duration of a normal match, i.e. 90 to 94 minutes including any additional time. Data collated during extra time does not form part of this study.



The team analyses were conducted during the three group-stage matches.

On an individual level for each position, 29 matches were analysed and between 52 and 82 pieces of data were collected during the competition. To make the results easier to understand, the figures presented in this study have been rounded off to the nearest multiple of 5.

To make sure that our analyses are reliable and comparable, we have chosen the five categories of runs recognised in modern football studies, notably:

1. Men's football study by: V. Di Salvo et al.(2008)
 - walking <7.2km/h; jogging <14.4km/h; moderate running <19.8km/h;
 - high-speed running 19.8km/h to 25km/h; and sprinting >25km/h over a distance of up to 20m.
2. Women's football study with speeds adapted to women by: M. Mohr, P. Krusturup et al. and J.Bangsbo (2008)
 - walking <6km/h; jogging <12km/h; moderate running 15 to 18km/h; high-speed running >18 to 25km/h and sprinting >25km/h.

Although we have taken running categories from previous female studies into account, for this study we have adapted some distances and running speeds based on our experiences and training research.

We believe that there is too great a difference between 19.1km/h and 25km/h for the same running category (high-speed running), knowing as we do that at these running speeds, some players can call on the aerobic system whereas others on the anaerobic alactic system. For the purposes of training, we believe it is important to conduct a more precise analysis of the different distances covered between these speeds in this study.

We have therefore separated high-speed runs, well-known in studies as ranging from 18km/h to 25km/h, and maximum sprints of >25km/h into three distinct categories. This enables us to determine whether there is a significant difference between these three running speeds during a match, and also to determine which speed is used most often by female players and in which position.

We have retained the normal moderate running speed, but have not separated walking, small strides and jogging. These categories have been placed under "low-speed running", as in this study we have chosen to concentrate on the most important running speeds in football.

In fact, one can only talk about basic speeds for performance with speeds of 12-13km/h up to 16-17km/h.

This speed is essentially used to retain possession, to change the pace of the game and to regroup defensively.

By contrast, running at speeds of between 19km/h and 21-22km/h is characteristic of a counter-attack, a call for a long ball while on the wings or a full-back running back quickly to the initial defensive position.

We have purposely not taken backwards running into account; this type of running does, however, require eccentric running and has certain value, particularly for certain positions.

Although we have not analysed this specific type of running, we do recommend that it is worked on during training with all of the variations of body position used during a match.

On the basis of these comments, the observation categories in our study are:

1. walking and running at low speed: up to 12km/h
2. moderate running: 12.1km/h to 18km/h
3. running at high speed: 18.1km/h to 21km/h
4. optimum sprinting: 21.1km/h to 25km/h
5. maximum sprinting: >25km/h



Results and analyses

1. HEIGHT OF PLAYERS AND DURATION OF MATCHES

The average height of the teams at the FIFA Women's World Cup 2011™ was 1.67m; the highest average was Germany with 1.72m and the lowest average was Japan with 1.62m. The tallest individual player was 1.87m, and the smallest player was 1.52m.

Although three of the four semi-finalists were among the tallest teams in the tournament (Sweden 1.72m, the USA and France 1.68m), world champions Japan (1.62m) were the smallest team, followed by Colombia (1.64m). Out of all the players in the tournament, only four were at least 1.80m tall (1.80m/1.87m).

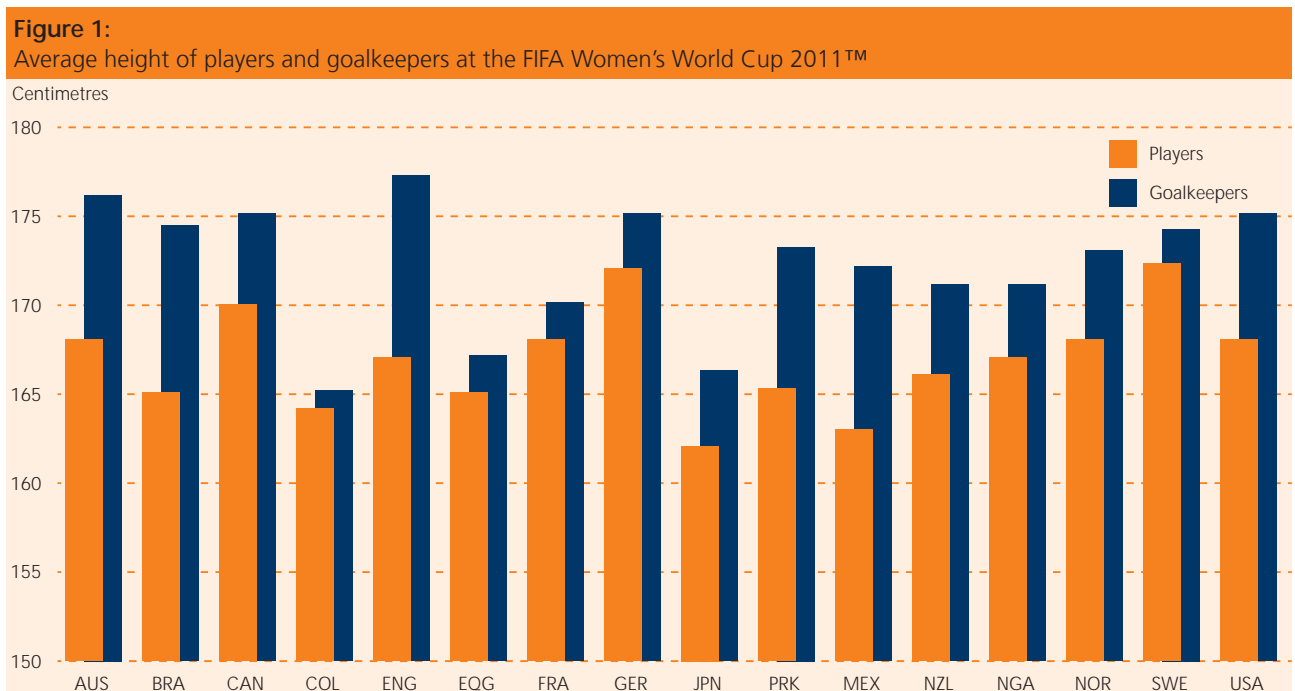
This data confirms that height is not conducive to good performances by teams in modern-day football and particularly not in women's football. Furthermore, two of the tallest teams were eliminated at the end of the group stage and even finished at the foot of the final ranking.

Modern-day football requires different qualities for good performances and for players to be top class.

In terms of goalkeepers, the team average was 1.72m; the tallest was 1.85m and the smallest was 1.62m. The average height of the goalkeepers of the four best teams was 1.75m, the tallest being 1.79m. These heights appear to be rather small for goalkeepers, especially with a view to coming out for balls in the air. There are other vital qualities such as explosiveness and muscular strength in the legs and the upper body, not to mention technical aspects for goalkeepers as well as their play with the ball at their feet, which is absolutely crucial these days, as well as personality, which came to the fore during the competition.

Duration of matches

The average duration of matches was between 92 and 95 minutes with additional time (without taking extra time into account), whereas the average actual playing time, 57'27, was higher than the same figure for the FIFA Women's



World Cup China PR 2007™ (53'40) and even for the 2010 FIFA World Cup South Africa™ (54'04). This figure also increased between the group stage (56'56) and the knock-out stage (more than 60'). This data backed up the spectacle of many matches, with speed, commitment right up to the final whistle and very few stoppages thanks to the fighting spirit of the majority of teams.

2. ANALYSIS OF TOTAL OVERALL DISTANCES COVERED IN A MATCH

An analysis of the average overall distances covered by all of the teams together reveals an average overall distance of 10,215m, with 55m of maximum sprints, 235m of optimum sprints, 395m of high-speed runs, 2,330m of moderate runs and 7,200m – or 70.5% of the match – of low-speed runs. As mentioned above, these averages were calculated from the players who played the full match. (Table 1)

The analysis of the average distances covered by the male players of Germany, England and Spain shows that there is a difference between male and female players, notably in terms of sprints and high-speed runs. Some differences may be attributable to the running speeds used in the studies. The results recorded reveal the great distances covered by female players during the course of a match: 13,880m overall, with 335m in maximum sprints and 640m in optimum sprints as well as 975m at high speed. These performances are comparable to those of male players, particularly in terms of the overall distance, with men covering 12,000-14,000m. The percentage figures of 0.5% in maximum sprints and 2.3% in optimum sprints, or 2.8% altogether, confirm the difference between women's and men's sprints as men register a total of 5.1% in maximum and optimum sprints. When it comes to high-speed runs, men register 9.9% compared to 6.7% for women.

The other figures, i.e. 93.3% and 90.1% in moderate runs and at low speed, bear witness to a relative balance between women and men in these areas.



The difference in their percentages for maximum sprints can also be explained by the fact that the studies on the maximum speed for men are calculated as of 24km/h as opposed to the 25km/h used in our study. (Figure 2)

Table 2 is a general summary of the average distances covered in a match by the 16 teams at the Women's World Cup 2011, together with their average running speeds. These results illustrate the average performances of each team during their three group-stage matches.

The difference between the average total distance run by the teams that covered the greatest distances – the USA with 10.990km, Canada with 10.580km and Japan with 10.470km – and the team that covered the shortest distance – Nigeria with 9.240km – was more than 1.5km. These figures can first of all be explained by the average speed of their players over the course of a match, i.e. more than 7.1km/h for the teams mentioned above as opposed to 6.0km/h for Mexico, and 6.3km/h for Nigeria and Equatorial Guinea. This difference can also be looked at from a purely

athletic and physical point of view, with some teams having greater aerobic endurance than others.

There was, however, more of a balance in the total distance covered by certain teams, most notably England (10.805km), New Zealand (10.770km), France (10.480km) and Sweden (10.220km). The difference between the four best teams in the tournament was just 770m, whereas the difference between some of the teams eliminated in the group stage was 1.340 km. Several teams covered similar distances in both the first and second halves, although the performance of all of the teams did drop slightly (by an average of 2.74%) in the second half. However, France, Sweden, Brazil, the USA, Korea DPR and New Zealand ran 0.8% further in the second half.

This difference does not appear to be significant in terms of the results obtained by the teams during the group stage. In fact, factors such as a change in tactics, a new team set-up during the match and a different style of play are often reasons that can explain variations in distances from one half

Table 1										
Analysis of the average total distances covered in a match by the teams during the group stage (3 matches)										
Total	Maximum sprint >25km/h	% Maximum sprint	Optimum sprint 21.1-25km/h	% Optimum sprint	High-speed run 18.1-21km/h	% High-speed run	Moderate run 12.1-18km/h	% Moderate run	Low-speed run < 12km/h	% Low-speed run
10,215	55	0.5%	235	2.3%	395	3.9%	2,330	22.8%	7,200	70.5%
Analysis of the total average distances covered by the players in the German, English and Spanish male leagues										
Total	Maximum sprint >24km/h	% Maximum sprint	High-speed run 21.1-24km/h	% High-speed run	Moderate run 19.1-21km/h	% Moderate run	Jogging 11.1-19km/h	% Jogging	Trot, walk, backwards run 0-11km/h	% Trot, walk and backwards run
11,400	220	2.0%	330	2.9%	550	4.8%	3,300	28.9%	7,000	61.4%
The comparison with the values of the German, English and Spanish players shows the differences in the distances covered by women and men, in particular in sprints and high-speed runs. These differences are due to some extent to the different speed categories used in the studies.										

Figure 2

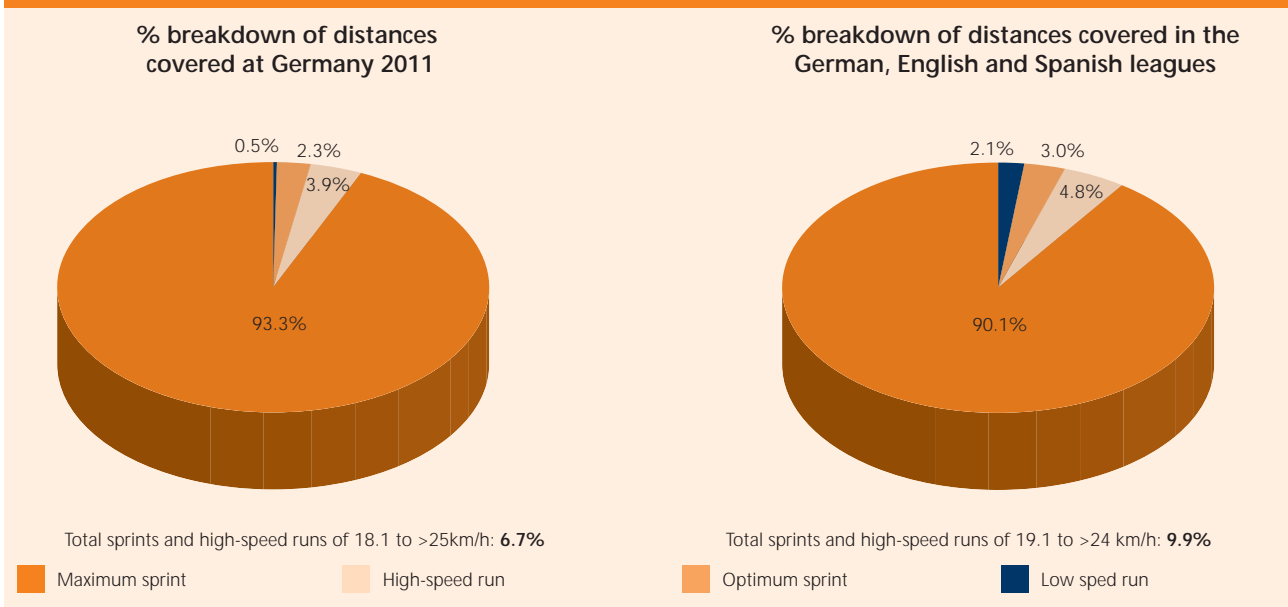


Table 2

Analysis of the total distances covered at each speed by the teams in the FIFA Women's World Cup 2011™

Teams	Total distance in a match (m)			Maximum + optimum sprint 21.1>25km/h		High-speed run 18.1-21km/h		Moderate run 12.1-18km/h		Low-speed run 0-12km/h
	Total	1 st half	2 nd half	Total (m)	Speed	Total (m)	Speed	Total (m)	Speed	0-12 km/h
Equatorial Guinea	9,500	4,950	4,550	285	23.9	370	19.4	2,125	14.4	6,730
Nigeria	9,240	4,640	4,600	245	24.2	310	19.1	1,805	14.4	6,880
Japan	10,470	5,305	5,165	240	23.9	370	19.3	2,840	14.3	7,020
Korea DPR	10,360	5,160	5,200	290	24.1	460	19.4	2,430	14.5	7,180
Canada	10,580	5,315	5,265	380	24.2	515	19.4	2,590	14.5	7,095
Mexico	10,050	5,125	4,925	155	24	445	19.3	2,730	14.4	6,720
USA	10,990	5,490	5,500	330	24	460	19.2	2,820	14.4	7,380
Brazil	9,350	4,650	4,700	310	24	350	19.2	1,760	14.4	7,030
Colombia	10,020	5,015	5,005	290	23.9	395	19.4	2,225	14.4	7,110
Australia	9,840	4,995	4,845	290	23.9	350	19.3	2,050	14.3	7,170
New Zealand	10,760	5,420	5,340	265	23.9	425	19.3	2,840	14.3	7,240
Germany	10,375	5,305	5,070	320	24	420	19.3	2,515	14.4	7,120
England	10,805	5,410	5,395	305	24.1	445	19.3	2,730	14.3	7,325
France	10,480	5,280	5,200	270	24.2	370	19.5	2,500	14.3	7,340
Norway	10,570	5,285	5,285	290	23.7	400	19.3	2,300	14.3	7,580
Sweden	10,220	5,085	5,135	310	24.2	360	19.2	2,200	14.2	7,350

to the next. The mental aspect could obviously also be taken into consideration.

Finally, the data relating to the distance covered in each half is comparable to figures in various studies into men's professional football, which have mentioned drops of between 2% and 9% in the second half.(Figure 3)

The graph that compares the total distance covered by various teams and players shows a difference of 1.330km between the 11.230km run by the seven top-class "FIFA all-star" players and the 9.900km run by the 18 top-class Danish and Swedish players. The average distance covered by the 16 teams in the group stage was 10.215km. These results are primarily indicative of the players' very good level of fitness but they also underline the influence of the players' individual fitness levels on the performance of a team. The difference in the distances covered by the players in the Women's World Cup 2011 and the Swedish and Danish top-class players (2008) shows the level of progress made by women at this level in the last few years.

Comparing the figures to those obtained from the Brazilian league (10.015km) and the Spanish league (11.400km) confirms that there is little difference between the distances covered by the best women's teams and men's teams (Figure 4). Analysing the total distances covered by the four semi-finalists in the group stage and then in the knock-out stage reveals some very interesting information as it indicates significant differences between the teams' performances in the two stages, most notably an average increase of 3.6% in the overall distance covered and of 21.7% in maximum and optimum sprints. There was, however, a 9% drop in high-speed runs by both Japan and the USA, but a 12% increase by France and little change in the figures for Sweden. These figures not only confirm an increase in the total distance covered but above all an increase in speed during this final phase with more than 25% at high speed.

This performance during the group stage and during the final stage shows that the qualified teams had good physical fitness levels and had prepared well for the tournament,

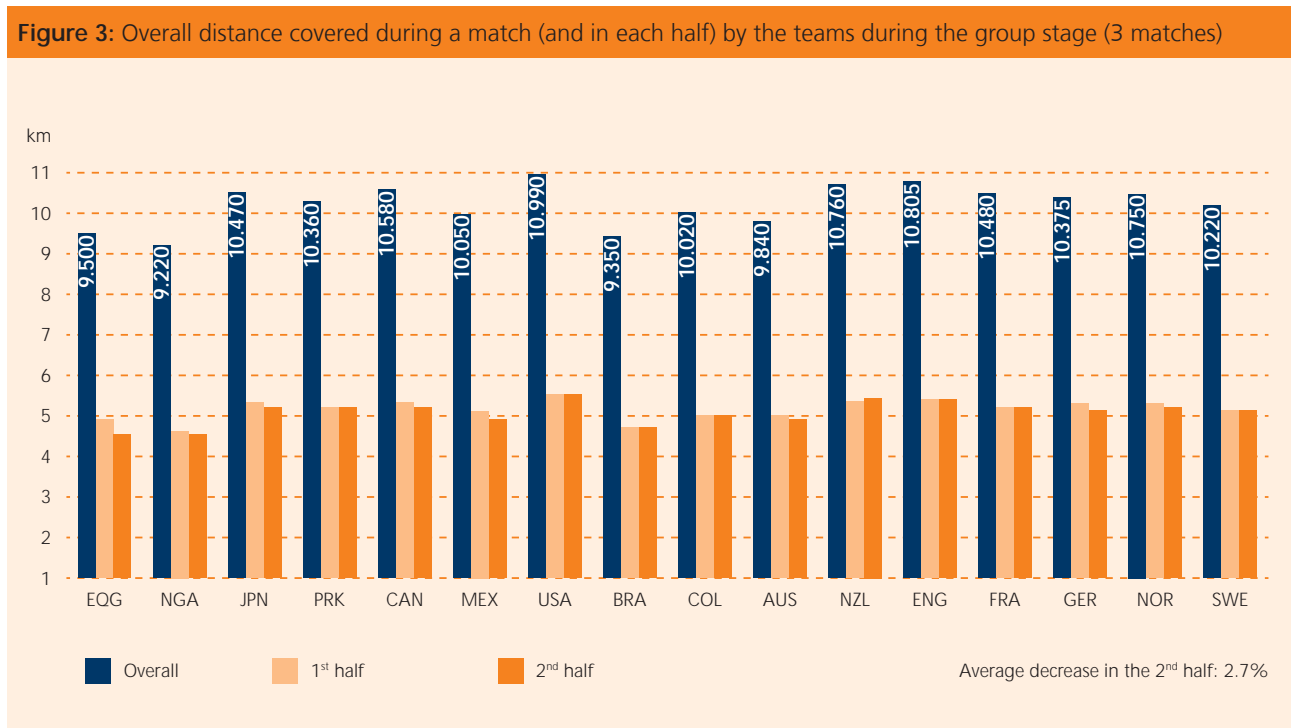


Figure 4: Comparison of the total distance covered during a match (overall and in each half) by the teams at the FIFA Women's World Cup 2011™ and men's teams

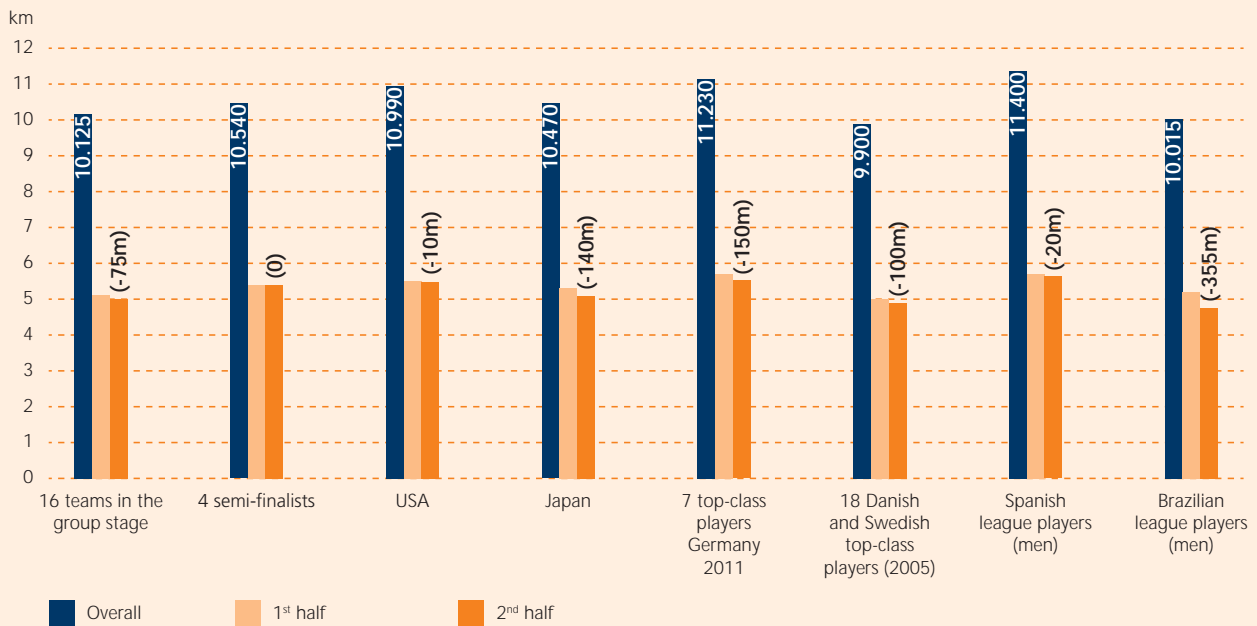


Table 3

Total distances covered by the four semi-finalists between the group stage (3 matches) and the final stage (3 matches)

Teams	Overall distance (m)		Maximum + optimum sprint 21.1 - >25km/h		High-speed run 18.1 - 21km/h		Moderate + low-speed run <18km/h	
	Group stage	Final stage	Group stage	Final stage	Group stage	Final stage	Group stage	Final stage
Japan	10,470	10,600 +1.3%	240	275 +12.7%	370	330 -10.1%	8,855	9,945 +11%
USA	10,990	10,760 -1.3%	330	340 +2.6%	460	420 -8.7%	10,200	10,000 -2%
Sweden	10,220	10,325 +1%	210	280 -9%	360	360 0%	9,560	9,945 +1.3%
France	10,480	10,820 +3.1%	270	325 +17%	370	420 -11.9%	9,840	10,075 +2.3%

Average increase in the overall distance in the final stage: 3.6% / Increase in sprints: 6% / Decrease in high-speed runs: 2.1%

The 570m that separated the six best teams in the FIFA Women's World Cup 2011™ from the six least-performing teams with regard to the average total distance covered during a match (10.560km v. 9.990km) are not the only reason for the differing results obtained by the teams. Other physical factors and above all the playing characteristics also play an important role.

even scientifically. Furthermore, recovering well between matches and good training sessions also enabled players to maintain their form throughout the competition. The context of the knock-out stage, when the best and most experienced teams came up against each other, should also be taken into consideration (Table 3). The 570m that separated the six best teams in the competition from the six least-performing teams with regard to the average total distance covered during a match (10.560km v. 9.990km) are not significant in terms of the results obtained. Other physical factors and above all the main characteristics of the game are more significant.

3. ANALYSIS OF SPRINTS AND HIGH-SPEED RUNS

If we analyse the maximum speed (>25km/h), we find a team average of 55m with a difference in distance ranging

from 90m (Canada) to 20m (Mexico). The average distance of a maximum sprint was 13.7m, ranging from 16.1m for Canada and 11.5m for Japan and down to just 7.5m for Mexico. The number of sprints at maximum speed also varied from team to team. The average was 4 sprints, ranging from 1 to 12 sprints in a match depending on the player and position. The average speed of a team's maximum sprint was 25.7km/h.

By analysing the data by position, it becomes clear that attackers and wide midfielders make the most sprints, with speeds slightly higher than the average. (Table 4) In terms of optimum sprints (21.1km/h to 25km/h), with results that ranged from 290m for Canada and 190m for Nigeria and down to 135m for Mexico, we notice a greater distance in optimum sprints in comparison to the maximum speed (180m). Germany had the biggest differences between these sprints, with 220m more at optimum speed than at maximum speed. The teams' average distance

Table 4

Number of sprints (maximum and optimum) run by the teams in the group stage with their distances (in metres)

Teams	Maximum sprint >25km/h			Optimum sprint 21.1-25km/h			Total maximum and optimum sprint 21.1 and >25km/h		
	Total distance (m)	Number of sprints	Average sprint distance (m)	Total distance (m)	Number of sprints	Average sprint distance (m)	Total distance (m)	Number of sprints	Average sprint distance (m)
Equatorial Guinea	50	4	12.4	235	17	13.8	285	21	13.5
Nigeria	55	3	14.9	190	13	14.6	245	16	15.3
Japan	40	3	11.5	205	14	14.2	240	17	14.1
Korea DPR	45	3	14.8	245	18	13.6	290	21	13.8
Canada	90	6	16.1	290	22	13.8	380	28	13.5
Mexico	20	2	7.5	135	11	12.3	155	13	11.9
USA	60	4	15.0	270	19	14.2	330	23	14.3
Brazil	75	5	15.7	235	16	14.5	310	21	14.7
Colombia	55	4	14.3	235	19	12.3	290	23	12.6
Australia	40	4	11.1	250	18	13.8	290	22	12.8
New Zealand	35	3	13.0	230	16	14.2	265	19	13.9
Germany	50	4	14.6	270	17	15.8	320	21	15.3
England	50	4	11.7	255	17	14.9	305	21	14.5
France	55	4	15.0	215	14	15.3	270	18	15.0
Norway	50	3	15.5	240	15	16.0	290	18	16.1
Sweden	60	5	12.8	250	16	15.6	310	21	14.7
AVERAGE	55	4	13.7	235	16	14.3	290	20	14.0



in optimum sprints was 14.2m, i.e. 0.5m more than at maximum speed. The greatest team distance was 15.6m, the shortest 11m. The number of sprints, however, was higher, with some teams completing more than twice as many as others, an average of 16 sprints per match and per team, with 22 by Canada and just 11 by Mexico. The average speed of an optimum sprint was 22.5km/h.

This data underlines the fact that women players sprint at optimum speed more frequently than at maximum speed in a match. This running speed is registered when players are escaping markers, calling for a pass when in spaces, making diagonal runs, dribbling and one-on-ones.

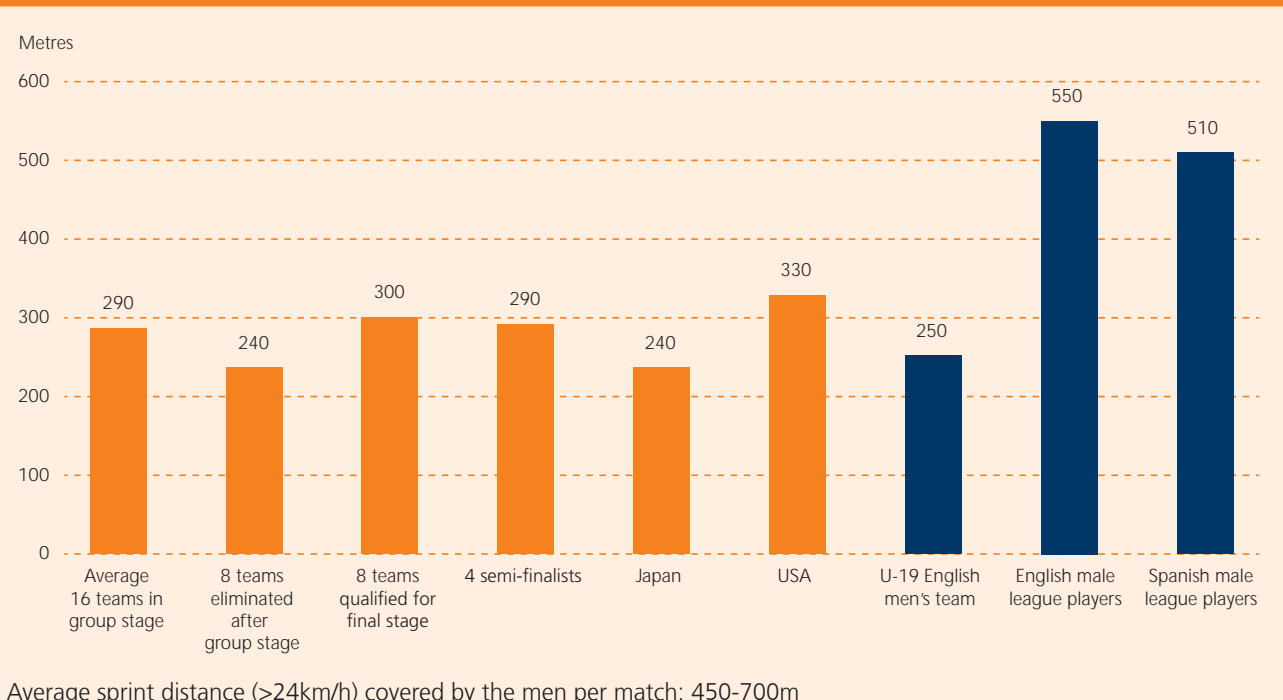
By analysing the individual data for each position, we see that it is often midfielders and wingers who most often use this type of optimum sprint of between 21km/h and 25km/h.

By adding together the distances of the two sprints (maximum sprint + optimum sprint, 21.1km/h to >25km/h), the teams' average was 290m. The Canadian team once again performed the best with 380m in sprints. The best teams in the tournament completed sprints of between 300m and 330m, i.e. nearly 90m more than world champions Japan and more than 100m more than some of the weaker teams.

With regard to the results by team, at this speed, it is noticeable that the Anglo-Saxon teams covered the greatest sprint distances: Canada (380m), the USA (330m), England (305m) and even Germany (320m). Nevertheless, Brazil and Sweden (310m) also performed well.

Figure 5 compares the total sprint distances (maximum + optimum) of teams during different phases of the competition, and also compares the figures with those

Figure 5: Comparison of sprints (maximum and optimum > 21.1km/h) run by the teams at the FIFA Women's World Cup 2011™ and professional English and Spanish male players



of certain men's teams. The difference between the USA (330m; 23 sprints of 14.3m) and Mexico (155m; 13 sprints of 11.9m) seems to underline the importance of sprints in terms of the result, as we will see later in the analysis of the number of goals scored. The USA scored six of the ten goals scored in Group C. Mexico scored only three of the 18 goals scored in Group B, in contrast to Japan who scored six (240m in sprints; 17 sprints of 14.1m). Although there is very little difference between the best teams, we will see later that it does underline the importance of speed in terms of match results.

The men's and women's results in terms of sprints (i.e. men sprinting almost 50% more with sprint distances (>24km/h) of 400-600m) confirm once again that there is a major difference in this area, even though the women do cover greater distances than English U-19 men's teams.

The results in terms of the overall distances covered by teams in sprints during each half showed an average increase of 5.7% in the second half, although this figure rose to 11% for Japan. These figures are indicative of the increase in speed in the second half with more goals scored in the second half, particularly towards the end of matches.

Studies into men's football do not mention any significant differences between the distances covered at each speed in the two halves, but other analyses reveal a drop in the distances covered in the second half.

The results obtained in our analysis can be explained, on the one hand, by the methodology of our study, and on the other hand most certainly by the level of competition, its worldwide appeal and the speed of matches, which often pushed players to the very limit.

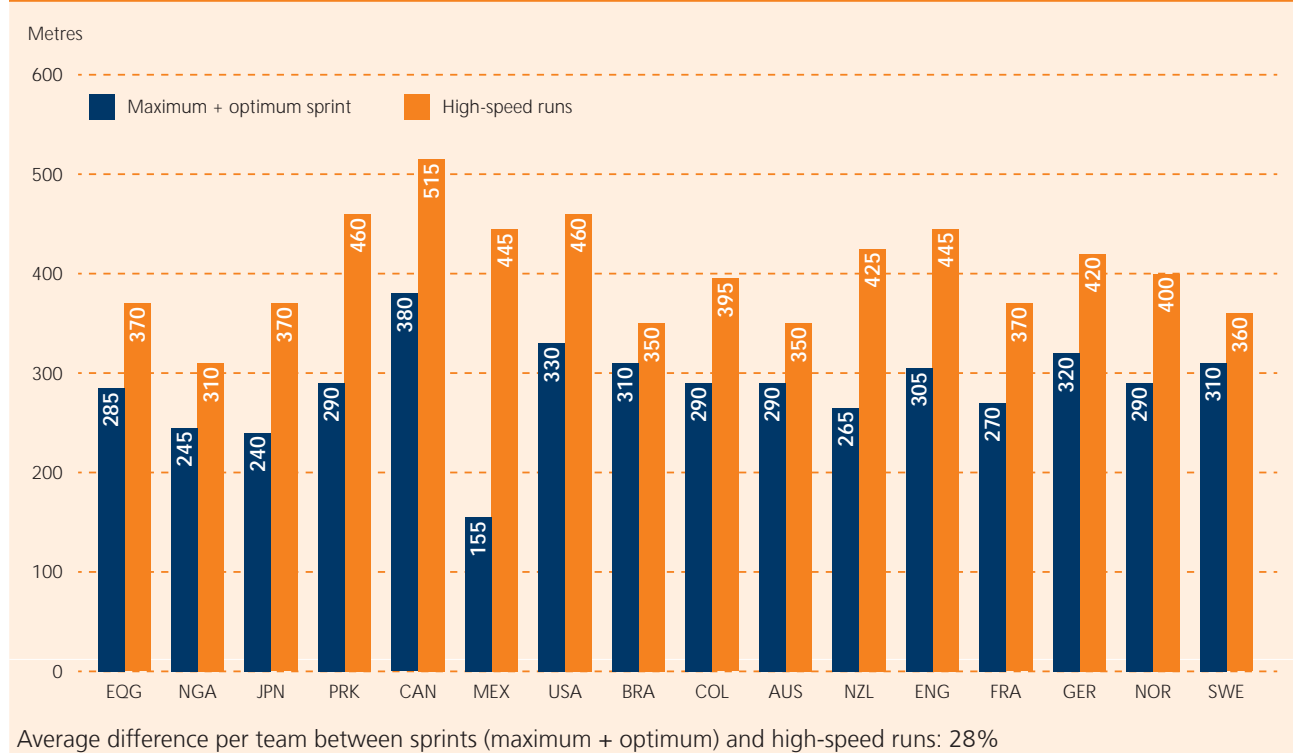


Analysis of high-speed runs

Figure 6 compares the teams' high-speed runs (18.1km/h to 21 km/h) and their maximum and optimum sprints (21.1km/h to >25km/h), and shows that teams ran 28% more in high-speed runs than in maximum and optimum sprints. This running speed is often used by players on the wings (wingers or full-backs) and some central players when attacking. This speed is also often used to regroup defensively and to get away from markers. The teams eliminated at the end of the group stage used this speed less often, running on average only 370m at high speed in contrast to the best teams' figures of 500m. There was little difference between the teams in these high-speed runs at an average of 19.4km/h: between 100m and 140m in total. However, it must be noted that some of the best teams – Japan, the USA, France, England

Germany and even New Zealand and Korea DPR – used high-speed runs almost 30% more than sprints (maximum and optimum). This difference between these runs is undoubtedly partly down to the style of play. The distances covered at this speed vary between 12m and a maximum of 20m, with this speed being used 20 to 30 times per match on average, and between 5 and 50 times depending on the position. On the basis of these figures, it must be noted, however, that the best results were obtained not only by teams who play the best football, but also by the teams that run most often at these elevated speeds, including sprints. If we combine these high-speed runs with maximum and optimum sprints, these speeds represented 11% of the match for the USA, 8.4% for Japan, 9% for France, 8.2%

Figure 6: Comparison of the total distance covered by the teams in sprints (maximum + optimum, >21.1km/h) and high-speed runs (18.1-21km/h) in the 3 group-stage matches





for Brazil, 8.6% for Sweden, 9.8% for Germany, 9.9% for England and 7.8% for Australia.

If we look at the teams eliminated at the end of the group stage, it was 7.8% for Nigeria, 6.2% for Mexico, 7.7% for Equatorial Guinea, 8.1% for Norway, 7.6% for Colombia and 8.5% for New Zealand.

These latter teams did, therefore, perform less well at these speeds.

As the figures for Canada (10.4%) and Korea DPR (9.4%), two teams eliminated at the end of the group stage, came close to the top performances, this confirms that high-speed runs are certainly important factors in the team's overall performance but not as crucial as technical-tactical aspects and the team's strategy during the match.

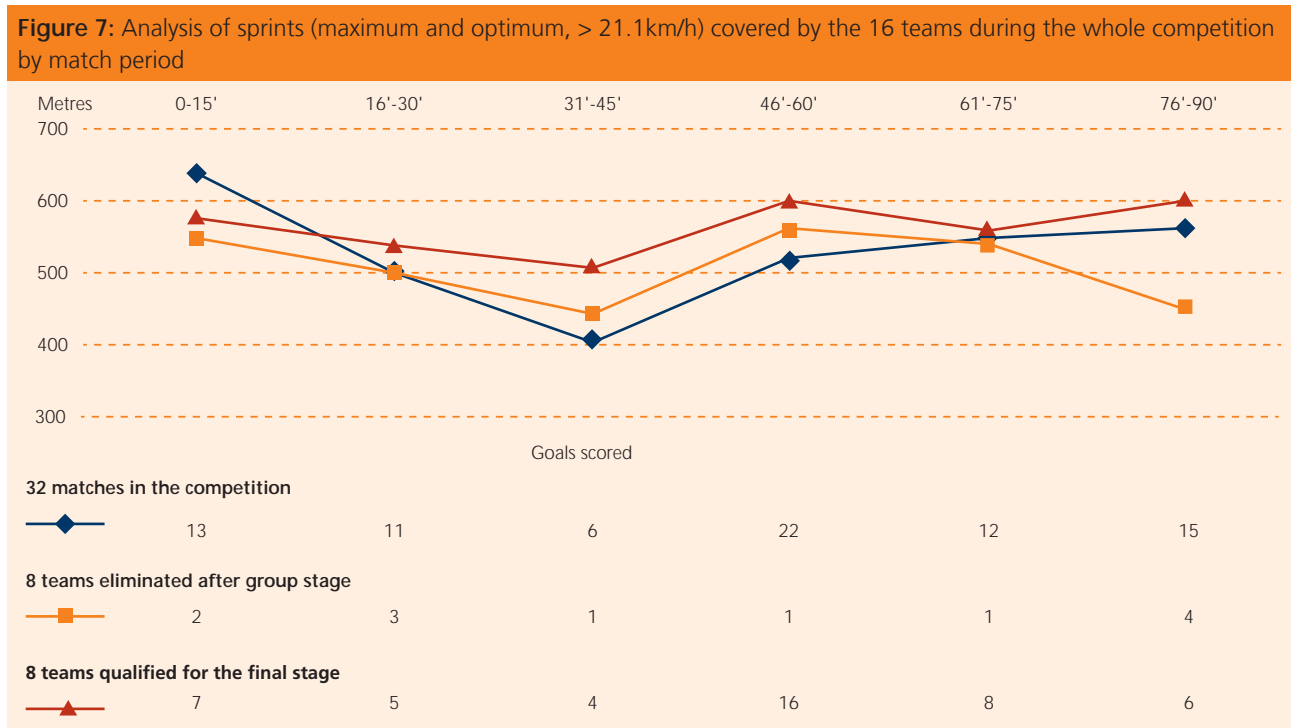
Recent studies into men's football mention average sprint and high-speed running (19km/h to >24km/h) distances of between 1,000m and 1,300m per player. The women's

average (700m), the USA's figures (790m), Brazil's data (660m) and France's results (640m) are in line with these studies, which confirm that the distances covered at these elevated speeds are in direct relation to a team's success. (Rampini et al)

Nevertheless, in the next chapter, we will look at the major influence that high-speed runs have on a team's performance, regardless of whether they have the ball or not.

Whereas the speed of high-speed runs and sprints (18.1km/h to >25km/h) does not have a significant effect on performances at these speeds, the same cannot be said of the distance covered in these runs and the players' ability to repeat sprints in great numbers, which are vital.

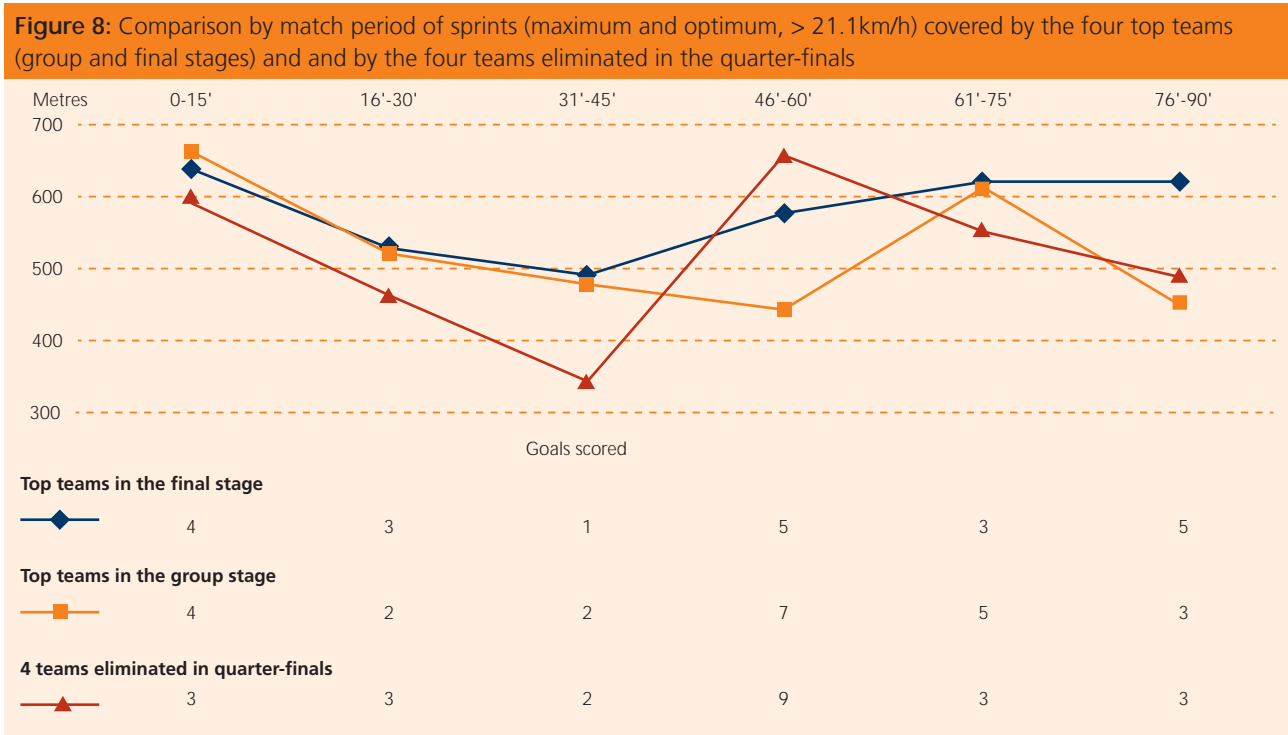
It should be pointed out, once again, that players' aerobic-anaerobic endurance capacity is essential to their ability to repeat these runs.



Correlation between speed and goals scored

This analysis, presented in figures 7 and 8, confirms the importance of speed in the conclusion and goals scored. Firstly, we notice that each team analysed started the match at intense sprinting speed before a major drop in performance at the end of the first half. This drop in performance coincided directly with the lowest number of goals scored, i.e. between the 31st and 45th minutes of a match (7.6%). The teams then picked up their speed again at the start of the second half (46th minute to 60th minute), which could be partially explained by the half-time break. This period also saw the greatest number of goals, most notably by the best teams, with 27% of all goals scored in this period (all of the teams), or 31.5% if we just take the best four teams. From the 60th minute onwards, there were two levels of sprints. First of all, similar figures or even an improvement

by the teams that qualified for the knock-out stage, and secondly, a drop in speed by the teams that were eliminated at the end of the group stage as well as by the teams knocked out in the quarter-finals. In the final quarter of an hour (76th-90th minute), the teams' speed increased again and the best teams scored more goals (18.5%). Taking all of the teams together, 19% of all goals were scored in this final period of the match. It was the opposite for the eliminated teams, who scored very few goals, as they conceded many goals (25%-30% of all goals) during the closing period of the match. In terms of the sprints completed by the best teams, there was a progressive increase in distance covered in the second half, most notably between the 60th and 90th minutes of the match and also between the group stage and the knock-out stage. The difference in goals scored in this period and between the two phases of the competition (8 goals in the



first stage and 6 goals in the final stage) can be explained by the fact that the matches were more balanced affairs against stronger opponents, and also by other tactics in this period of the match.

As we have already mentioned, during this Women's World Cup, the increase in sprints in the second half had a positive effect on the number of goals scored in this period: 62% as opposed to 38% in the first half over the course of the entire competition.

As we have already said, this figure can be explained by the scope of our study. In fact, our analysis looks at players taking part in a major knock-out competition.

Pressure, the intensity of matches, the importance of the result and the enthusiasm that surrounds the event, as well as the player's significant levels of motivation all affected this intensity.

Finally, the drop in speed that was most notably observed at the end of the first half (31st -45th minute) is worthy of our attention as it was also in this period that just six of the 79 goals (scored in the 90 minutes of ordinary time) were scored by all of the teams and just two (of 38) by the best teams.

How should this drop in speed from the 31st to the 45th minute be interpreted?

- By the fact that matches often start at very high speed?
- By a team's strategic decision to try and hold on to a certain scoreline until half-time?
- Maybe it is the benefit of introducing new players for the second half?
- Fatigue (physical fitness, hydration, concentration, etc.) is definitely not the only factor as the performances picked up in the second half, with 62% more goals scored

There are many questions for women's football coaches and technicians to find answers to and adjust their training accordingly (methods and forms of training, intensity, recovery).

4. DISTANCES COVERED WITH AND WITHOUT THE BALL

This specific analysis focuses primarily on the four best teams, who all qualified for the semi-finals.

First of all, during this analysis, our observations show that the four best teams had the highest rate of possession over their six matches, averaging 52% as opposed to the 48% registered by the teams that were eliminated at the end of the group stage. World champions Japan enjoyed 55.1% of possession, whereas the USA and France had 53% and Sweden 47%.

In terms of the distances covered in metres, three of the four semi-finalists ran further with the ball than without it (between 3,200m and 3,450m), Sweden being the exception as they ran 3,405m without the ball and 2,800m with the ball. Like Sweden, the eight teams knocked out at the end of the group stage also ran more without the ball (3,275m) than with it (2,780m). There was very little difference between the two finalists, Japan and the USA, with the ball (3,450m as opposed to 3,385m). There was, however, a greater difference in their figures without the ball as Japan (3,420m) ran 270m further than the Americans (3,150m).

This insignificant difference between the distances covered with and without the ball, particularly among the best teams, underlines the importance of escaping from an opponent and of running while the team is in possession of the ball, but also of the entire team – including the attackers – needing to regroup in defence without the ball, as we will see in the analysis by position.

This similarity between the distances with and without the ball is backed up by statistics on players in Spain's *La Liga* (Figure 9).

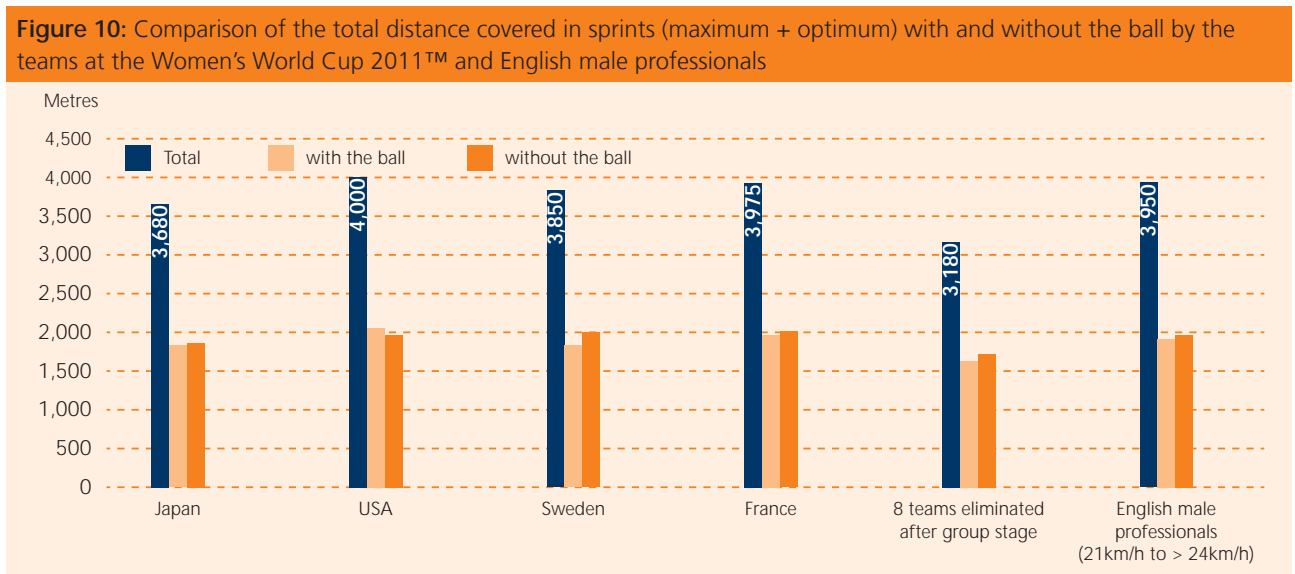
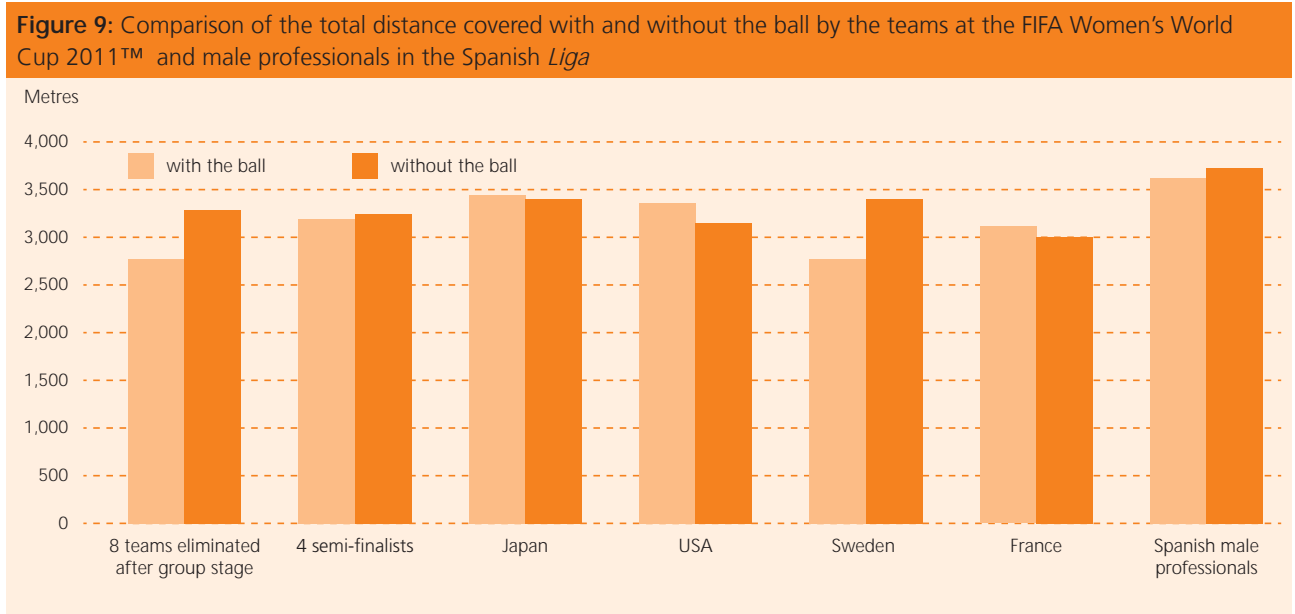
An analysis of the total distances covered in sprints (maximum and optimum) with and without the ball by the best teams and by those eliminated at the end of the group stage reveals the same tendencies as the overall

distances covered. Thus, in sprints with the ball, there is quite a significant difference between the four best teams, which covered an average of 3,680m, and the eight teams eliminated at the end of the group stage, which covered 3,180m on average (Figure 10).

The two finalists in the Women's World Cup covered greater distances in sprints with the ball. Japan (+120m) covered

90m more at this speed with the ball than the USA (+30m), in contrast to Sweden (+190m without the ball) and France (+45m without the ball).

This similarity between runs with and without the ball bears witness to the increase in high-speed runs in modern high-level football, including with the ball. Women have also made great progress in this area.



The sprints completed in each half in the final stage also back up previous observations while confirming the 9% increase in this speed in the second half, both with and without the ball.

Furthermore, the high number of goals scored in the second half (68%) also backs up the correlation between sprints and goals scored, as already mentioned.

These sprint distances with and without the ball confirm the high speed of the best teams in this Women's World Cup, particularly in the final stage. The teams' high-speed runs and dynamic commitment during matches were vital parts of their armoury, from the very first whistle right until the very end of a match.

To bring this chapter to a close and to back up our observations, we would like to refer to the official technical report on the FIFA Women's World Cup Germany 2011™, which mentioned not only the quality of the play on show but also the different styles of play of teams that were able to quickly change the pace of the game, such as Germany, France, Japan, England, Canada and Australia, but also the fact that the successful teams (Japan, the USA, France, Sweden and Germany) were all capable of moving their defensive unit forwards and backwards without losing pace or increasing the distances between the individual

team lines. Furthermore, a number of teams showed great tactical maturity in terms of how they organised their units and also showed flexibility in their style of play, with players constantly on the move.

This evaluation is in close correlation with the physical performances observed during this report. The match performances of the teams mentioned above are unquestionable evidence of players being in peak physical condition. However, these teams covered the greatest distances, both overall and in sprints, but also and especially when they were in possession of the ball. The distances covered in sprints (maximum and optimum) without the ball enabled certain teams to put the ball-carrier under extreme pressure. It is also true to say that players can only use all of their technical qualities for the duration of a match if they are in peak physical condition.

What are the reasons for these differences in performance among the teams?

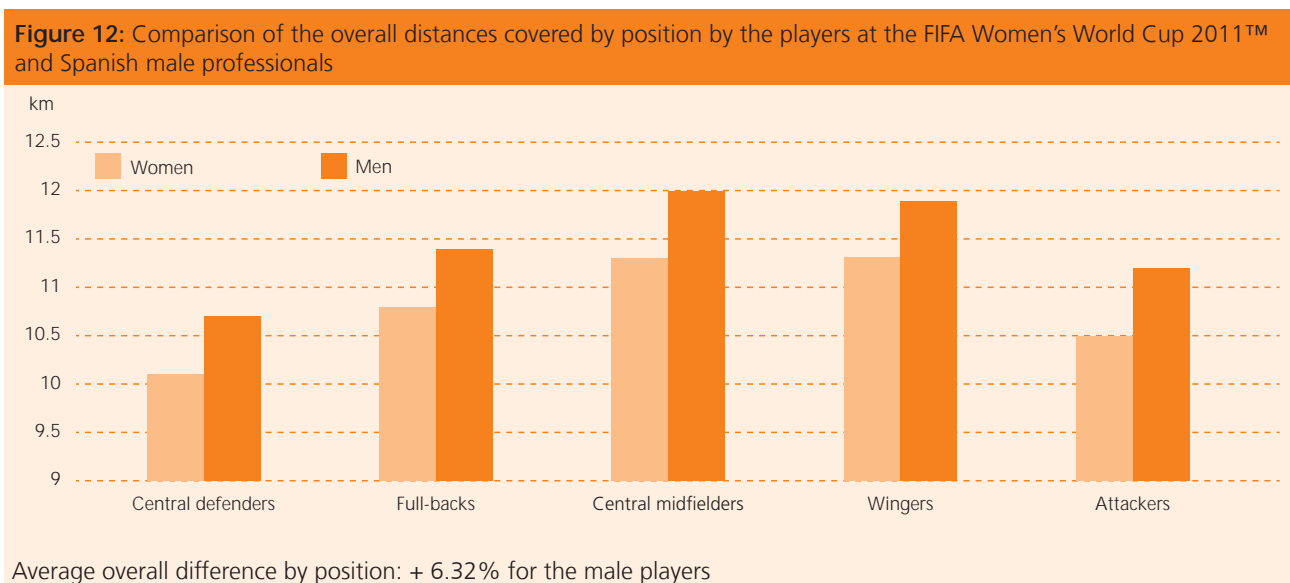
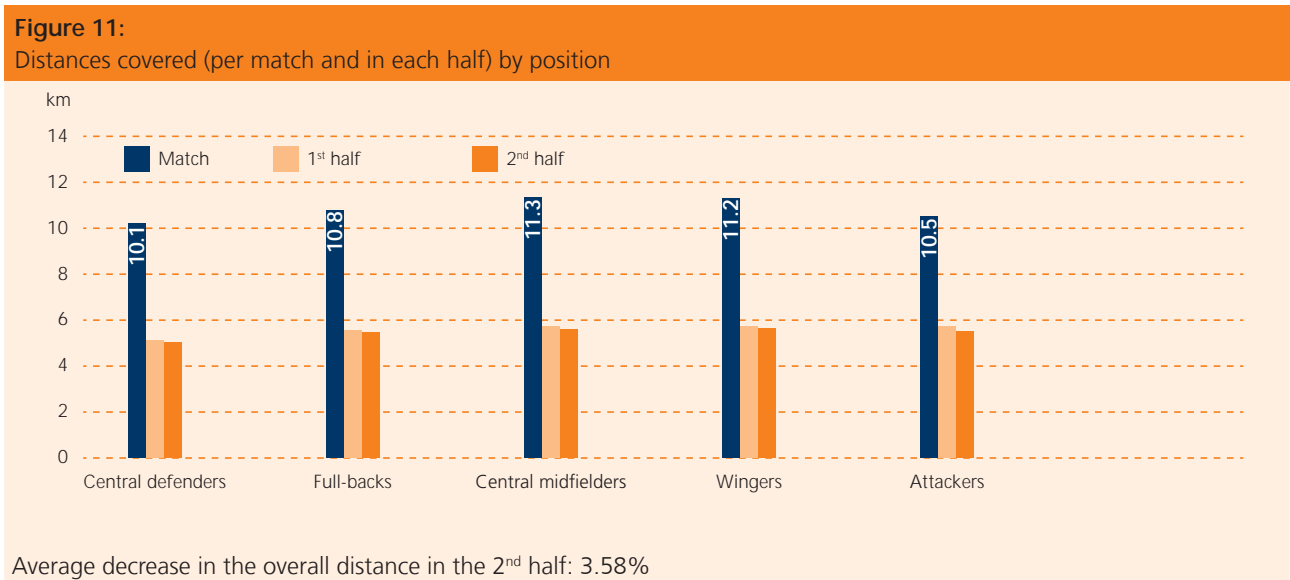
- System and formation (4-4-2 / 4-2-3-1 / 4-3-3)
- Style of play, tactical organisation, match strategy and changing systems during the match
 - short passes, fast (Japan), deep passes, play on the wings (USA), build-up play, fast (France)

Table 5

Comparison of the overall distances (in metres) covered by position in moderate and low-speed runs

Position	Total overall distance			Low-speed run 0-12 km/h			Moderate run 12.1-18km/h			Average speed of moderate run
	Total	1 st half	2 nd half	Total	1 st half	2 nd half	Total	1 st half	2 nd half	
Central defenders	10,160	5,120	5,040	7,410	3,710	3,700	2,230	1,190	1,040	14.3 km/h
Full-backs	10,850	5,460	5,390	7,440	3,720	3,720	2,600	1,330	1,270	14.4 km/h
Central midfielders	11,350	5,720	5,630	7,550	3,750	3,800	3,130	1,635	1,495	14.3 km/h
Wingers	11,280	5,700	5,580	7,500	3,745	3,755	2,835	1,450	1,385	14.4 km/h
Attackers	10,460	5,270	5,190	7,320	3,660	3,660	2,190	1,135	1,055	14.5 km/h

- long, deep balls (Norway, Equatorial Guinea)
- defensive play, deep-lying or high defensive line, pressurising
- attackers' regrouping and defensive play
- runs (diagonal, forward, lateral)
- Differences between the players (individual level, athletic, physical and mental characteristics)
- Bringing on new players in the second half
- The competition itself (match, group stage, final)
- Culture and spirit of the game
- Team or individual players' fatigue
- The level of preparation
- Winning spirit! Hunger for success! Will to win!



5. ANALYSIS OF DISTANCES BY POSITION

This analysis by position is an important part of our study. The data collected will allow us to make some training recommendations for coaches.

As in previous studies, our analysis of the overall distances for the entire match and in each half, at both moderate speed and at low speed, reveals differences between the positions.

As shown in table 5 and figure 11, our study confirms the significant distances covered by the midfielders, but it also reveals little difference in terms of the players' low-speed runs (230m) as opposed to a significant difference at moderate speed with a difference of nearly 1,000m between the midfielders and the attackers.

This running speed is often used, most notably by midfielders, to move around the pitch and escape markers. The average speed of moderate runs (14.3km/h) enables us to estimate a running speed of between 70% and 80% (of the maximum heart rate), which is indicative of an average running speed of 75% to 80% of the maximum aerobic speed (MAS).

The data also reveals the number of passes completed by each position, with a success rate of 73.8%, which is

indicative of the majority of teams having a good mastery of this essential football skill.

The overall distances covered over the entire match and in each half show a slight drop for each position in the second half, but only of 2%-4%, which is often also the case in men's football.

Figure 12, which compares the overall distance by position for men and women, shows an average difference of 6% between the distances covered by Women's World Cup players playing in the same position as Spanish male professionals; the biggest difference was with the attackers, with male attackers running 8% more than their female counterparts. As in the men's game, the longest distances were covered by the midfielders and full-backs.

With regard to sprints (maximum and optimum) and runs at high speed, there were significant differences between the positions at each speed. As is often the case, the attackers covered the greatest distance in maximum sprints (125m) and optimum sprints (360m), and they also completed the highest number of sprints (an average of 30 sprints (maximum and optimum) per match). (Table 6) Wingers (27 sprints) and full-backs (22 sprints) and central defenders (21 sprints) used these speeds more often than central midfielders (16 sprints). As already mentioned, optimum sprints (21.1-25km/h) are used (with and without

Table 6

Total distance (in metres), average speed and number (per match) of maximum sprints, optimum sprints and high-speed runs plus recovery time between sprints, by position

Position	Maximum sprint (>25km/h)			Optimum sprint (21.1-25km/h)			High-speed run 18.1-21km/h			Recovery time between sprints (maximum and optimum)
	Total	Average speed	No. of sprints	Total	Average speed	No. of sprints	Total	Average speed	No. of sprints	
Central defenders	50	25.5	3	210	22.2	18	335	19.3	40	5.30
Full-backs	100	25.7	4	280	22.2	18	460	19.3	40	3.40
Central midfielders	80	25.7	3	205	22.2	13	440	19.3	39	5.45
Wingers	110	25.8	4	330	22.2	23	540	19.3	47	5.40
Attackers	125	25.5	6	360	22.1	23	465	19.3	41	3.40

the ball) 30% more than maximum sprints (>25km/h). As demonstrated by the analysis of speed by team, the distances covered by these positions from one half to the next remains very consistent. An important aspect of this study is knowing the recovery time between two sprints (maximum and optimum). The difference between the

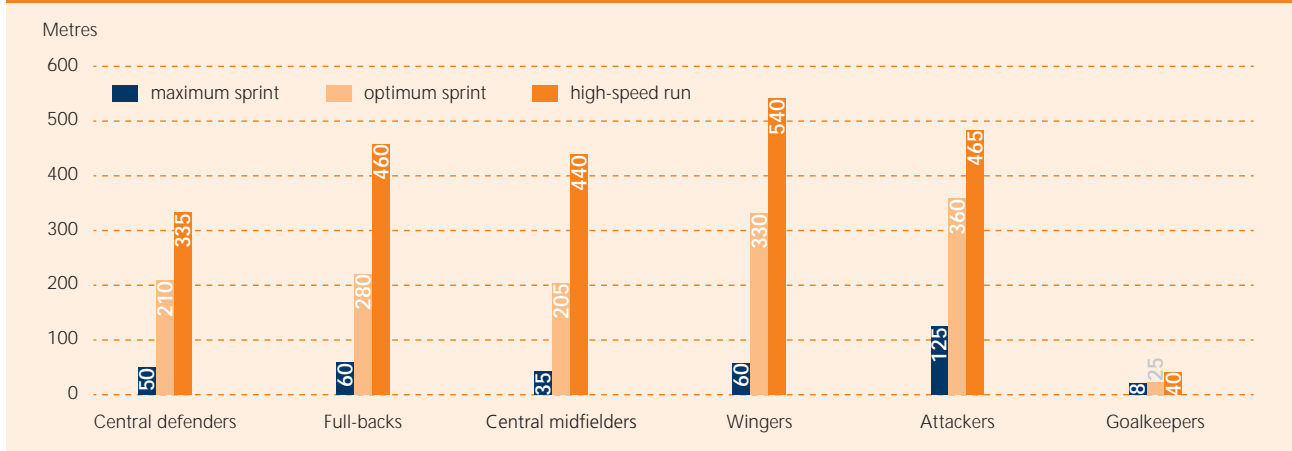
average recovery time of attackers (3'40), and central defenders (5'30) and some individual attackers (1'50) merits our attention, however, particularly for training. Table 7 provides more detailed information on maximum sprints by position, including a comparison with professional male players to explain the difference at this speed

Table 7

Comparison of maximum sprints by players at the FIFA Women's World Cup 2011™ and male English and Spanish national team players by position/ Difference between female players in the same position (in metres)

Position	Women's average Maximum sprint (>25km/h) (maximum sprint speed 28.9km/h)			Men's average Maximum sprint (>24km/h) (maximum sprint speed >30km/h)			Difference in individual performance by position					Sprint speed (km/h)
	Total distance	Sprint distance	No. of sprints	Total distance	Sprint distance	No. of sprints	Match	Players	Total distance	Sprint distance	No. of sprints	
Central defenders	50	12.5	4	180	20	8	USA-COL	Defender USA	160	17	9	25.6
								Defender COL	20	9	2	26.2
Full-backs	100	17	6	250	22	12	CAN-FRA	Defender CAN	140	23	6	25.8
								Defender FRA	65	21	3	25.9
Central midfielders	80	16	5	230	20	11	ENG-JPN	Defender ENG	25	25	1	25.8
								Defender JPN	125	14	7	25.5
Wingers	110	18	6	260	23	11	EQG-BRA	Defender EOG	120	24	5	25.6
								Defender BRA	155	25	6	26.5
Attackers	125	18	7	270	19	14	SWE-USA	Defender SWE	335	22	15	25.8
								Defender USA	50	16	3	24.3

Figure 13: Total distance covered in maximum and optimum sprints and high-speed runs by the different positions during the whole competition



The position-specific analysis of the distances covered, particularly in high-speed runs and sprints, is another argument for individualised training that takes account of both the physical characteristics of the individual players and the special demands of each position.

between men and women. The analysis of the individual performances of female players in the same position reveals some interesting differences over the course of a single match, although there is little difference in terms of sprint speed. However, the results recorded show a maximum sprint speed of 29.7km/h achieved by a player during a match as well as speeds of 27km/h to 28km/h by attackers and wingers.

Average distances of 13m to 20m, average speeds of 26km/h to 27km/h for maximum sprints and 22.2km/h for optimum sprints, an average of 3 maximum sprints per match per team (5 to 15 sprints for attackers) and 14 to 16 optimum sprints (20 to 30 sprints depending on the position), are key figures to improve speed training sessions. Like the figures already mentioned in the collective analyses, the figures on high-speed runs (18.1km/h to 21km/h) reveal important information for training sessions for this type of running.

First of all, these runs are often used in each position in a match (40 to 45 times per game) but over very short distances (10m to 15m) and with an overall distance that is nearly the same as for optimum sprints. The average speed for this high-speed run is 19.3km/h, even though some players reach 20km/h. Depending on their position, some players can cover total distances of more than 500m at this speed, with the number of repetitions ranging from 45 to 50.

These three important speeds are used by the average position as follows: 47% at high speed, 38% in optimum sprints and 15% in maximum sprints. Central defenders only use 8% maximum sprints, as opposed to attackers with 25%, wingers with 38% and full-backs with 40%, which once again confirms the importance of these types of high-speed runs in these positions (Figure 13).

In terms of the greatest distance in each position in high-speed runs and sprints, a study into English men's football

Table 8

Analysis of the physical performance of goalkeepers

Goalkeeper	Total distance (m)			Maximum sprint			Optimum sprint			High-speed run			Moderate run	Walk and low-speed run
	Total	1 st half	2 nd half	Total metres	No. of sprints	Sprint speed	Total metres	No. of sprints	Sprint speed	Total metres	No. of sprints	Sprint speed	Total	Total
Solo USA (1.75m)	6,420	3,220	3,200	5	1	26.4	20	2	22.2	55	5	19.1	530	5,810
Kaihori Japan (1.70m)	5,840	2,910	2,930	0	0	0	20	2	22.3	40	5	19.1	490	5,290
Lindahl Sweden (1.79m)	6,800	3,490	3,310	0	0	0	45	2	21.8	45	4	18.8	445	6,295
Angerer Germany (1.75m)	5,959	2,980	2,970	0	0	0	15	2	21.5	60	5	19.3	420	5,425
Andreia Brazil (1.72m)	5,280	2,600	2,680	0	0	0	10	1	21.6	25	3	18.4	150	5,105

revealed the following: 1,300m for wingers (930m for women) and 1,230m for attackers (950m for women), i.e. the men's figures were nearly 22% higher than the women's. It should be noted, however, that high-speed runs are counted from 19.1km/h for men and 18.1km/h for women.

Analysis of goalkeepers

This brief analysis allows us to give some interesting general information, using the same observation categories as used for outfield players (Table 8).

According to the FIFA Technical Study Group, the five selected goalkeepers – Solo (USA, 1.75m), Kaihori (Japan, 1.70m), Lindahl (Sweden, 1.79m), Angerer (Germany, 1.75m) and Andreia (Brazil, 1.72m) – performed well throughout the tournament.

The average distance covered by the goalkeepers was 6.0km, with a significant difference between Lindahl (6.8km) and Andreia (5.280km). Runs at low speed (up to 12km/h) represented 91-92% of the distance covered, whereas runs at moderate speed accounted for 5-6%, with runs at high speed coming in at less than 1% and sprints (maximum and optimum) at 0.6-0.7%.

The difference in the overall distances covered by Solo and Andreia (1,140m) can certainly be explained by Solo's role in her team's build-up play, as she was often involved in the game by coming out of her penalty area to cover her defence. Her footwork ensured that she was efficient in restarting play and intercepting deep passes from the opposition. There is no question that these skills and her great presence helped her to perform to the best of her ability. This data is backed up by the distance that she covered at moderate speed (12.1km to 18km) as she covered 530m at 19.1km/h whereas Lindahl covered 445m. There was no significant difference between the overall distances covered in each half.

An analysis of the runs at high speed reveals that little distance was covered, and especially the fact that the observed goalkeepers did not complete any sprints at maximum speed. Only Solo had an average maximum sprint distance of 5m per match (maximum: 15m in one match with two repetitions) and at an average speed of 26.4km/h that was better than the best attackers. The goalkeepers most often intervened at pace by using optimum sprints (total distance of 20m) and with high-speed runs (total distance of 45m).

Table 9

Comparison of distances covered (in metres) by goalkeepers at the FIFA Women's World Cup 2011™ and goalkeepers on the English men's national team

Goalkeepers	Total overall distance	Maximum sprint distance >25km/h	High-speed run distance 18.1-25km/h	Moderate run distance 12.1-18km/h	Low-speed run distance 0-12km/h	Total overall distance	Maximum sprint distance >25km/h	High-speed run distance 19.9-25km/h	Moderate run distance 14.5-18km/h	Low-speed run distance 0-14km/h
FIFA Women's World Cup 2011™	6,042	2	45	410	5,585					
Average English goalkeepers						5,610	11	55	220	5,325
Solo (USA)	6,420	5	75	530	5,810					
Best performance of English goalkeepers						6,420	25	90	310	5,995



The average speed was 21.5km/h in an optimum sprint (highest speed during a match: 24.8km/h by Andreia) and 19km/h at high speed (19.6km/h by Solo).

During matches, goalkeepers essentially use these speeds to come off their line to engage an opponent in a one-on-one situation, to intercept a ball played in behind the defence, and in certain cases, to run quickly to the edge of their penalty area to launch an attack either with their feet or with their hands (Lindahl).

Given the physical capacities of goalkeepers, the speed of their actions and acceleration are not really recognised as key parts of their game, unlike their speed of perception and reaction and the technique that is specific to goalkeeping. Nevertheless, in view of the average sprint speed (maximum and optimum) of the goalkeepers at this Women's World Cup (21.7km/h), and on the evidence of some matches in this competition, it is fair to say that some of the goalkeepers lacked the necessary strength.

Furthermore, the FIFA technical report identified some weaknesses in goalkeepers coming off their line for aerial balls; weaknesses that are maybe due a lack of height, a lack of technique or a lack of game intelligence, but certainly also due to a lack of ability to stabilise the upper body and a lack of power and speed, which also has an effect on a goalkeeper's technique and even on the goalkeeper's confidence, presence and courage.

For information purposes, at the end of this analysis you will find a comparison of the performances of these five goalkeepers with the performances of English male goalkeepers (Di Salvo et al/2008) (Table 9).

The results and figures for each position in terms of overall distance, and more specifically in high-speed runs and sprints, back up the idea of individual training based, on the one hand, on the players' physiological characteristics, and on the other, on the demands of each position.



6. ANALYSIS OF TOP-CLASS PLAYERS AND FIFA ALL-STAR PLAYERS

The seven players selected for this analysis were the three best goalscorers in the competition – Sawa (Japan), Marta (Brazil) and Wambach (USA) – and four other players from the “FIFA All-Star” team were chosen on the basis of their performances throughout the whole competition – Schelin (Sweden), Anonman (Equatorial Guinea), Cheney (USA) and Nécib (France).

The players selected are all attacking players who made their mark on their teams’ performances, both in terms of play and physically.

The overall analysis of the performances reveals a number of differences both in terms of the overall distances covered and their sprints. These differences are primarily down to the positions the players occupy in the team, as well as the style of play and tactical organisation. Individual technical and tactical skills, athletic capacity and personality are also factors that need to be taken into consideration in individual performances (Table 10). The total distance covered (overall and in each half) reveals that there are significant gaps between players like Marta (9.700km), Cheney (13.060km), Schelin (10.380km) and Sawa (11.480km).

The style of play and the activities of these players are very different. Marta and Schelin are pure attackers, while

Table 10

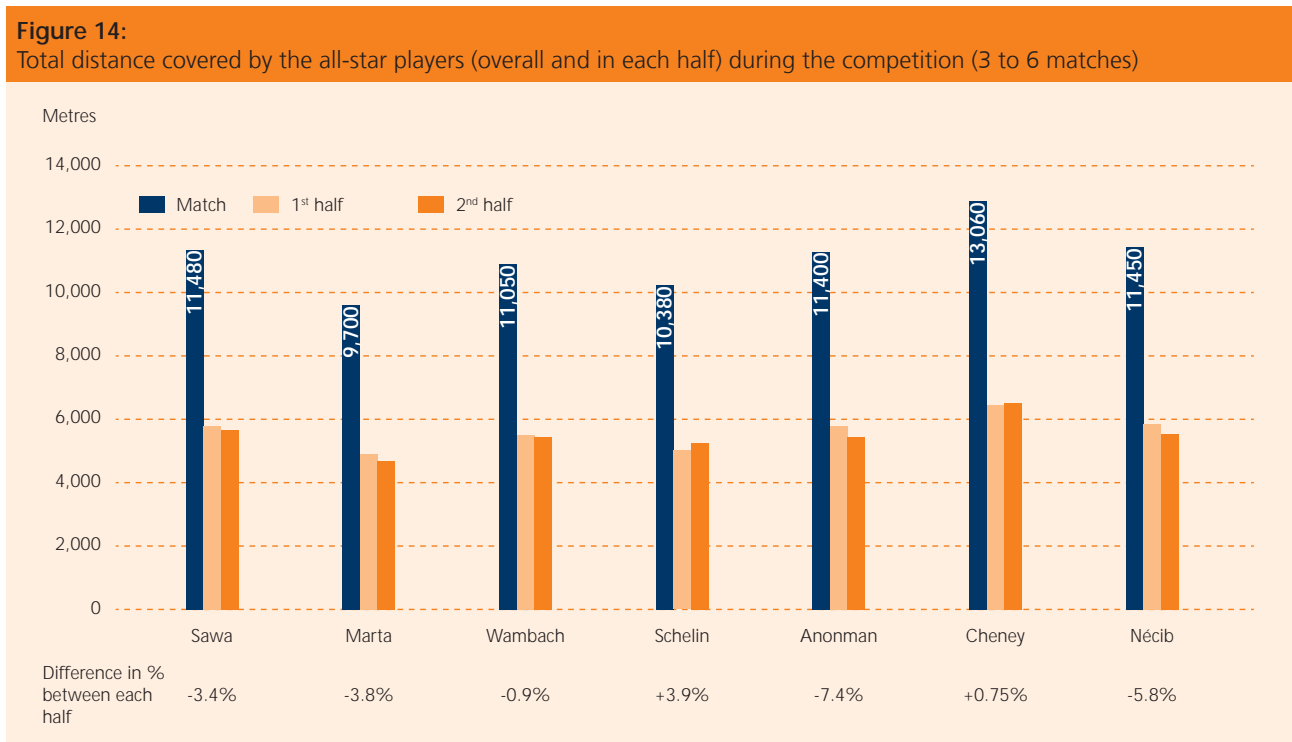
Total distance (in metres) covered by the all-star players in sprints and runs including number of sprints and average speed during the competition (3 to 6 matches)

Players	Maximum sprint distance >25km/h				Optimum sprint distance 21.1-25km/h				High-speed run distance 18.1-21km/h		Moderate run distance 12.1-18km/h	Low-speed run distance 0-12km/h	Overall distance covered	Overall speed during the match (km/h)
	Total distance	No. of sprints	Sprint speed (km/h)	Sprint distance	Total distance	No. of sprints	Sprint speed (km/h)	Sprint distance	Total distance	Run speed (km/h)				
Sawa Midfielder (JPN)	25	2	26.05	12m	190	13	22.4	15m	420	19.4	3,310	7,535	11,480	7.5
Marta Attacker (BRA)	240	11	26	23m	455	31	22	15m	460	19.3	2,150	6,395	9,700	7.2
Wambach Attacker (BRA)	95	6	25.5	18m	430	27	22.3	16m	535	19.4	2,820	7,170	11,050	7.0
Schelin Attacker (SWE)	245	11	25.5	22m	420	27	22.3	15m	470	19.3	2,080	7,165	10,380	6.5
Anonman Attacker (EQG)	65	6	25.7	12m	450	31	22.4	14m	700	19.4	2,880	7,305	11,400	7.2
Cheney Winger (USA)	50	4	26.3	15m	520	27	22.3	15m	825	19.4	3,880	7,785	13,060	8.2
Nécib Central mid- fielder (FRA)	20	2	25.1	10m	240	14	22.1	17m	500	19.2	3,210	7,480	11,450	7.5

Sawa and Cheney are first and foremost midfielders with another tactical register that requires them to move about a lot. The performance of the young Equatorial Guinea player Anonman, a real free spirit, who covered 11.400km, indicates a high level of activity and constant presence in all matches. She was the real leader of this African team, leading by example with her commitment. (Figure 15)

The comparison of the performances in each half reveals a drop of 6-7% in the distances covered in the second half. As we have already indicated, this drop is in line with certain figures from the men's game, which show decreases of 2-9% in the second half in the professional game. However, both Schelin (+210m) and Cheney (+50m) registered slight increases in the second half. The slight difference between the two halves and the result of this analysis (average of 11.500km) highlights the good aerobic-anaerobic endurance and excellent recovery capacity of these top-class players.

The average speed in a match (sprint, high-speed run, low-speed run, walk), meanwhile, is very well balanced among the players, at an average of 7.3km/h, which indicates the different characteristics and especially the positions of the top-class players. Thus, the difference between attacker Schelin (6.7km/h), midfielder Sawa (7.5km/h) and wide midfielder Cheney (8.2km/h) is down to their position and role in the team. Cheney's average speed of 8.2km/h certainly explains her performance during the matches, the large distances she covered – in all areas of the pitch – and the quality of her play. The findings of the speed analysis present a similar pattern as for overall distance, namely major differences between players depending on their position. Purely attacking players cover the same distances – between 400 and 500m – in optimum sprints (21.1km/h to 25 km/h). The large distance covered by Cheney – 520m – can be explained by how active she is across the whole attacking



area of the pitch and her fighting spirit throughout the tournament (Figure 16).

Although Brazilian player Marta covered less distance than the others overall (9.700km), as is often the case with attackers, she covered greater distances at maximum sprint speed (240m at >25 km/h) and at optimum sprint speed (460m at 21.1km/h to 25km/h). She also completed more sprints (42 repetitions) and covered the greatest distance in a single maximum sprint (23m), followed by Schelin (22m). The other players did not exceed 100m, with 2 to 6 sprints and an individual sprint distance of 10m to 15m.

Sawa's sprint performance is interesting: with a total distance of only 215m (25m maximum sprint and 190m optimum sprint), she covered the shortest distance at these speeds, but was not the slowest player. Having covered an overall distance of 11.480km, with 7.535km in low-speed runs (behind Cheney with 7.785km), she has the perfect profile for a midfielder, always in the right

position with intelligent runs to call for the ball and intensive and constant changes of rhythm.

She has the second-fastest average speed for the maximum sprint (26.2km/h), the fastest optimum sprint (22.4km/h) and also the fastest high-speed run (19.4km/h). In addition to her endurance, as the top goalscorer of the Women's World Cup, she is therefore also very explosive. In addition, she has very good technical and tactical skills, good perception of the game (reading the game, taking in information) and a very strong personality.

As we have already mentioned, in our study it is difficult to draw conclusions from these sprint findings and compare them with the men's game, where players can sprint at more than 28 km/h and, depending on their position, over more than 345m for South American international players (Rienzi et al/2000), 500m for young amateur Italian players (Castagna et al/2003) and 650m for Italian professionals (Mohr et al/2003). We prefer to highlight the fact that the average distance (more than 400m) covered in optimum



sprints is close to that covered by men in maximum sprints. The difference in the distances covered by all 16 teams and the four best teams is close to 50% greater among the top-class players.

In addition to their very good technical, tactical and mental skills, the top-class players no doubt also have physiological neuromuscular ability specific to speed.

To complete this analysis, we can confirm that the optimum sprint (21.1km/h to 25km/h) is used 12% more than the maximum sprint by these players.

The distance covered in high-speed runs (18.1km/h to 21km/h), in other words 90% to 120% of maximum aerobic speed (MAS)¹, is a regular speed in modern football. For certain studies, it is the most important running speed, with anticipative "cognitive" speed off the mark a key factor in game play, particularly in fast play.

This speed is often used by central and wide midfielders and full-backs. The differences identified in the performances analysed in this study, such as the 700m covered by Anonman compared to the 460m covered by Marta, are largely down to the positions they play in and their roles. The average running speed of 19.3km/h may already represent 120% of maximum aerobic speed for some players. Given male performances at a speed of 19.1km/h to 23km/h, expressed as a maximum aerobic speed (MAS) of 120% to 130%, and an average distance of 610m in a match (from 250m to 800m depending on the position), the

individual physical performances of the top-class players at this speed are very interesting.

In view of these results and on the basis of the figures by team, we believe that performances at this speed could certainly improve among all female players with individual training based on personalised aerobic speed (MAS), which can be ascertained using various specific pitch tests.

Finally, the recovery times between sprints (maximum and optimum together) are also important. The results obtained with these players are significant in explaining the number of sprint repetitions they do.

Attackers Marta, Schelin and Anonman had a recovery time of 2'20 to 2'50, while the others had a recovery time of a little more than 3 minutes. Compared with the average of 4'30 to 5 minutes for the teams, these times again confirm the good recovery capacity of these top-class players, which enables them to regularly change rhythm during the match and to maintain this intensity for the duration of the game. The differences in the physical qualities of these top-class players are in keeping with their athletic and physiological characteristics as well as their role on the pitch. However, their physical performances during almost all of the matches explain their major contribution to the game and their importance in the team. Allied with the mental strength essential to great performances, the importance of complex training combining technical, tactical and physical aspects is clear.

¹ Maximum aerobic speed (MAS), running speed reached at VO_2 max, i.e. maximum oxygen consumption during intense continuous and progressive effort primarily using the aerobic processes.

This speed is characterised as the speed that can be maintained for 6 to 8 minutes on average, using only these aerobic processes. MAS is equal to maximum aerobic power.

7. ANALYSIS OF THE FINAL: JAPAN v. USA 2-2 a.e.t. (1-1, 0-0) 3-1 PSO

In order to provide methodological information for coaches and confirm our findings, it is essential that we include in our report a brief analysis of the physical performance of the two teams in this spectacular final. This analysis was carried out over the normal match duration (90 minutes + additional time), without taking extra time into account. The analysis gives us a better understanding of the importance of the teams' physical performance and provides interesting information on the conclusion of the match.

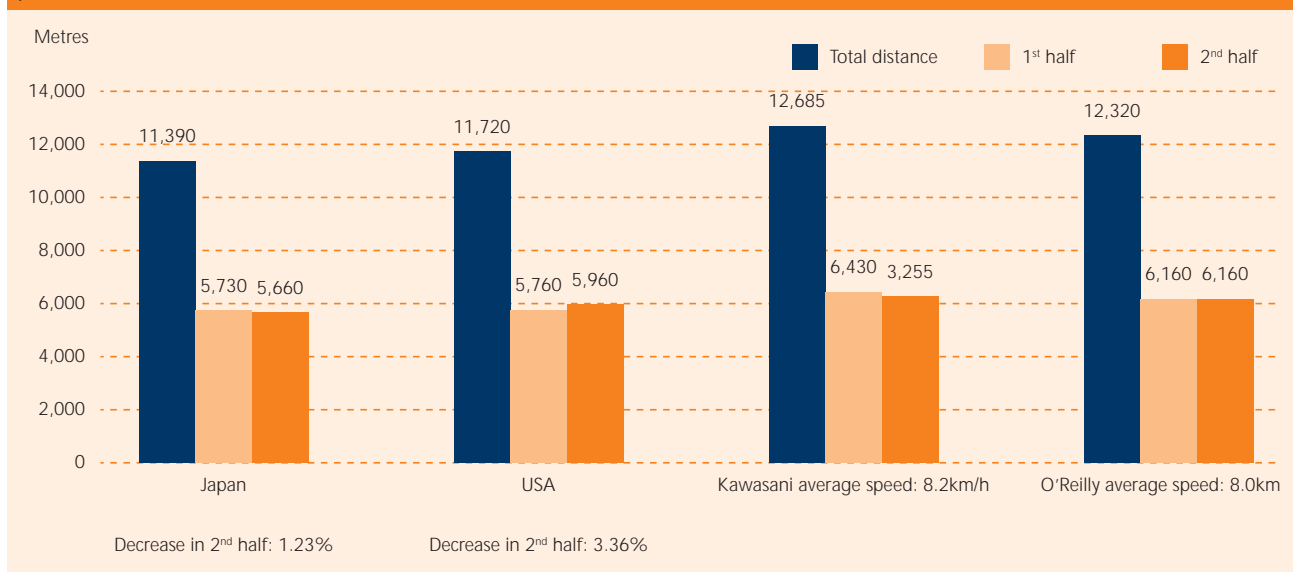
From a technical-tactical point of view the match was well-balanced, with differences in style and concept, but both teams put in major physical performances. The total overall distance of 11.390km covered by Japan was very close to the 11.720km covered by the USA, as are the distances covered in each half, with both teams having registered a slight decrease – 70m for Japan and an increase of 200m for the USA in the second half. The individual distances of 12.685km covered by Japanese attacker Kawasumi and

12.320km by US midfielder O'Reilly exceed the 10.600km covered by the Danish and Swedish international midfielders (H.A. Anderson et al/2010).

The average speeds of these two players (8km/h and 8.2km/h) underline their ability to run long distances during a match. The similar distances covered in the first and second halves (decrease of 175m for Kawasumi and the same distance as in the first half for O'Reilly) confirm the total commitment of these two players throughout the whole match.

With or without the ball, there were no major differences between the teams, both of which covered a greater overall distance without the ball: 2.9% for the USA and almost 10% for Japan. As for the total sprint distance (maximum and optimum, with and without the ball) the USA, who performed very well in this area throughout the competition, covered on average 3,970m while Japan covered 3,750m. However, both teams registered a drop in sprints in the second half: 260m for the USA and 380m for Japan. The teams were also well balanced in sprints with the ball, with the USA covering 190m more, although Japan

Figure 16: Comparison of the Japan v. USA final, overall distance by team and by match half, with the best individual performances (match duration: 92 mins)





performed better in the second half with 150m more, while in the same half the USA experienced a drop of 340m. When their opponents had possession, there was no difference between the Japanese (1,920m) and the Americans (1,950m) (Figure 17).

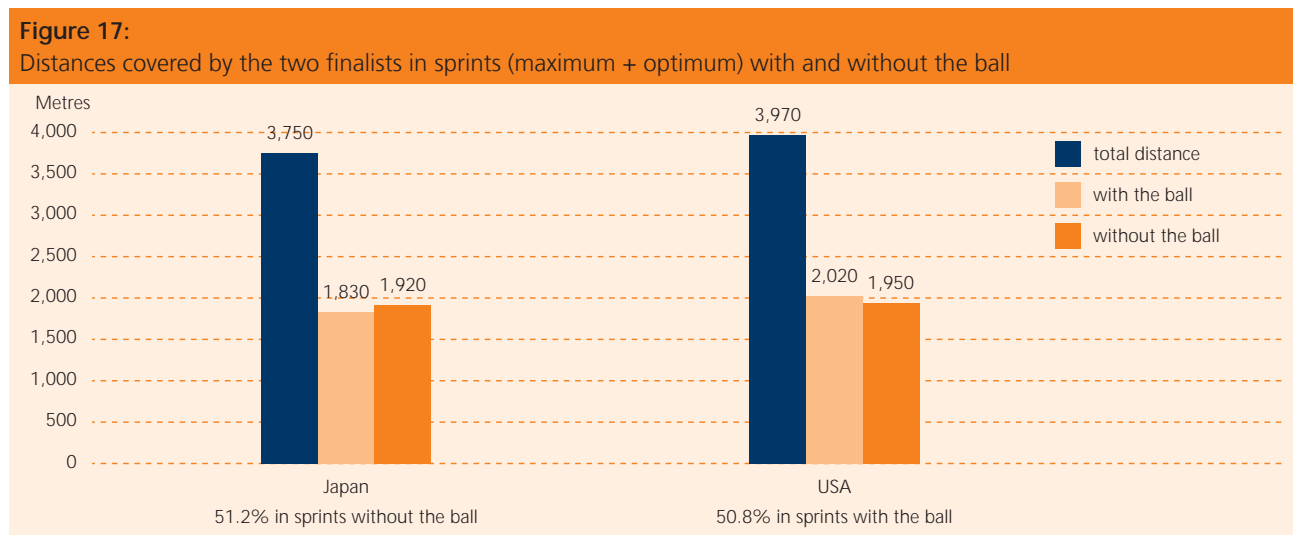
Based on these performances, we can observe that the differences in physical intensity between the two teams during the final were possibly due to physical problems (6th match and 3rd intense match of the competition with extra time), but also without doubt because of game concept, style of play, strategy and mentality. Indeed, we observed that, in the final, the Japanese coach made a number of changes to the team's organisation, in particular adopting a more compact shape and dropping deeper when defending. This may explain the decrease in sprints without the ball, particularly in the second half.

An individual analysis of the sprints (maximum and optimum) in the final again reveals how active Japanese centre forward Kawasumi (1,090m) and US wide midfielder Rapinoe were at this speed. The distance covered in maximum and optimum sprints (955m by Kawasumi and 700m by Rapinoe) together with high-speed runs (19.1km/h to 21km/h) amounts to an average total of almost 1,600m.

This performance is on a par with the average distance covered by male Spanish midfielders – 1,300m-1,400m. The best individual performances by male midfielders in sprints and high-speed runs (19.1km/h to > 23km/h) range from 1,450m to 1,600m (Di Salvo et al/2006).

At the end of this analysis, we can confirm that the physical performances in the distances covered, both with and without the ball, certainly form the basis of the quality of the spectacle in terms of the level of play and the speed throughout the match, even in extra time.

Moreover, in this match it was very interesting to observe two different styles of play come up against each other which correlated with the athletic characteristics of the players. On the one hand were Japan, with players who were small (1.62m on average/1.55m-1.71m) but dynamic, fast and with good stamina and a compact team that played short low passes with changes in rhythm, while on the other were the USA (1.68m on average/1.63-1.81m) who played long diagonal aerial passes, trying to find space for their athletic and powerful attackers. Both teams managed to find a style of play suited to their mentality and culture as well as the athletic and physical characteristics of their players.



8. CONCLUSION OF THE ANALYSES

The analyses carried out in this study highlighted total and partial distances covered by teams, individuals and positions. The analysis of the distances covered with and without the ball found an important correlation with the quality and style of play of certain teams. We observed a significant connection between the distances covered, with and without the ball, by the four best teams compared to some teams eliminated at the end of the group stage, who covered shorter distances with and without the ball. Differences in the performances of players are attributable in part to their position and their role on the pitch and also, especially in certain positions, to the players' better athletic and physical qualities. These results are backed up by the excellent performances of the top-class players in this tournament.

As in the men's game, when it comes to sprints it is the attackers who covered the greatest overall distances and the most repetitions in a match, but with average maximum distances of 12m to 25m. However, our analysis shows that some midfield players and some wide players (midfield or defence) also covered great distances in attacking sprints, often even with decisive action and quick defensive regrouping. The optimum sprint was used in distances 20% to 30% greater than the maximum sprint at this World Cup. However, depending on their position, the players used high-speed runs most often in a match. The sprint analysis reveals major individual differences in the distances covered by the very good players and those who performed less well. This applies to overall distances covered at all speeds.

The results of the analysis of recovery time between maximum and optimum sprints are interesting. There is a big difference between the players, particularly between particular positions; on average, the difference ranges from 3'40 for attackers to 5'30 or more for central defenders. Depending on the match and the individual, the gap between two sprints may be 1'30 for attackers

and almost 10 minutes for central defenders. We should pay particular attention to these results for speed and speed-power (strength) training.

A final comparison of the teams also reveals major differences both in overall total distances and sprints, with the results of some teams that were eliminated after the group stage reflective of their performances in the competition. The gap between them and the other teams was not so evident in the total distance, but in the speed and rhythm of play and the speed of the high-speed runs, both in terms of distance and number of repetitions. Given the underlying athletic potential of some of the players in these teams and the footballing quality of some of the players, optimal and more intensive physical training could certainly contribute to better performances, particularly at international level.

Despite their good physical performances other teams did not obtain the results they hoped for. Other important factors related to collective and individual play, strategy and mental preparation may have been at the root of these teams' below-par performance.

The comparative analysis of the best teams and top-class players allowed us to draw parallels between physical strengths and weaknesses and the individual match performances and the teams' results.

Finally, as we already know, the major differences between men and women are primarily in the areas of speed and power. This is mainly down to differences in strength, which is lower in women for various reasons (genetics, muscle mass, size of segments, etc.), including hormonal reasons (testosterone).

However, it is possible to boost speed and strength firstly by improving the quality of training, with activities at a greater intensity, less time between the training phases and, especially, demanding more in terms of the quality of work and commitment of the players. In this respect, the balance between training and recovery is essential.

On the basis of this analysis of the FIFA Women's World Cup 2011™, we can say without doubt that there is a

significant link between collective performances in a match, individual technical-tactical performances, the specific physical factors of the match and the mental factors.

CONSEQUENCES FOR TRAINING

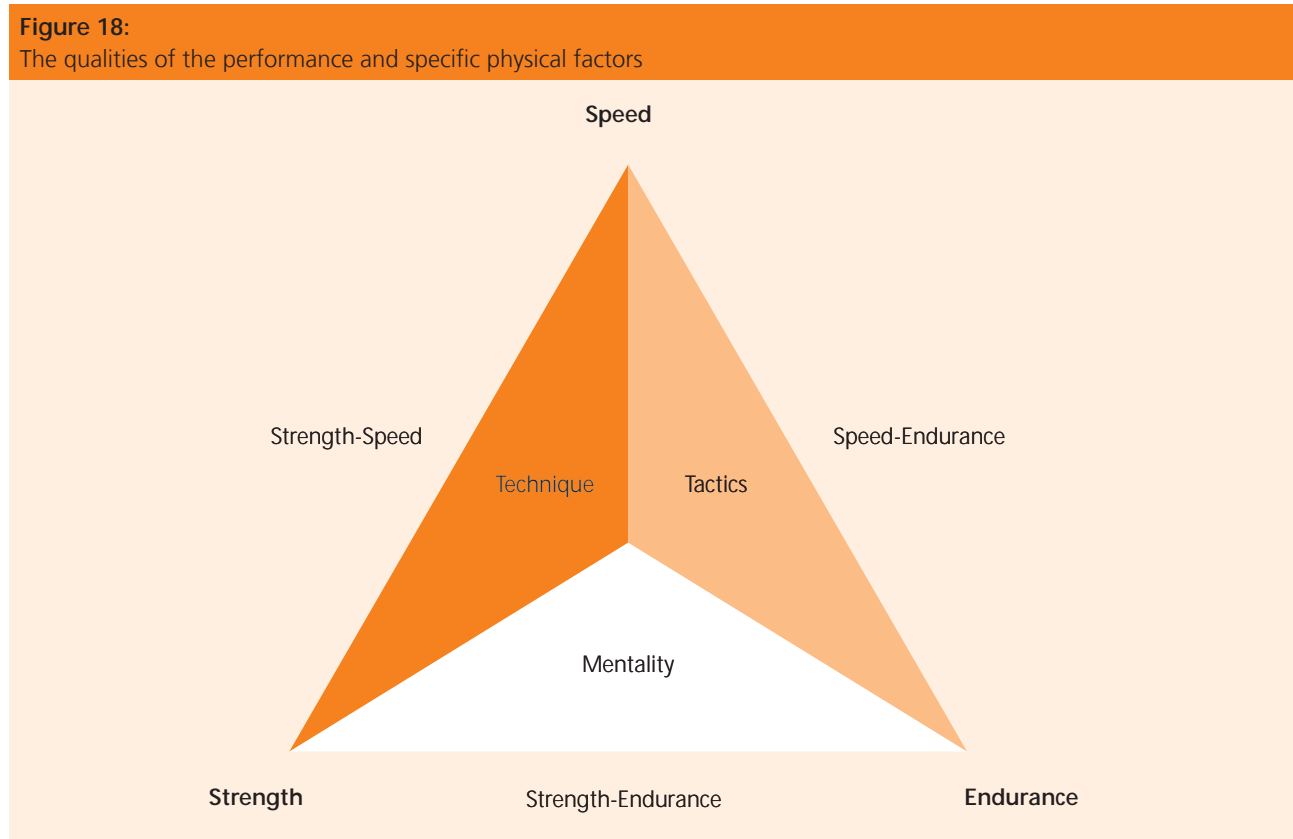
General points

Training methodology should centre on new trends in training, the integrated approach with the ball and the complex game. Group training sessions should cover all the match ingredients, not only the technical and tactical elements, but also the physical and even cognitive aspects. The intensity of the session should be as close as possible to real match conditions in terms of running distances, types of runs and sprints and recovery time. In addition, the intensity

of training should change from one session to the next. For example, do not always start training at the same intensity after warming up.

As recommended by J. Bangsbo, it is important to alternate between different rhythms. (For example, a session begins at an intensity of 75% to 80% of maximum heart rate (max HR), the next day at an intensity of 90% to 100% of max HR.) The pitch, the attacking and defensive zones, variation in the use of match surfaces and the running distances with and without the ball are key elements in the structure of a training session.

Individual training adapted to the player's qualities and abilities should be optimised and scheduled into the training cycles. Individual training should be a priority when training strength, endurance and coordination, particularly for young players.



Individual training should also be used for physical training for different positions, taking account of the skills used in those positions as well as the types of exertion, the distances, and even the opponents' attacks. Recovery time between exercises should also be applied depending on the players and the match.

We also recommend individual physical training (training based on the player's characteristics, her strengths and weaknesses) during training periods, particularly the weekly micro-cycle. Some countries have already incorporated these kinds of specific individual sessions (2 to 3 sessions a week) into their training cycles.

Finally, methodical training of young players, particularly in certain countries, should be reviewed and where applicable optimised, in line with the scientific training available in the major men's and women's footballing nations.

The four best teams also gave the best physical performances.

The top-class players covered overall distances and basic runs equal to those of very good male players.

Speed is the major difference between men's and women's football (almost 40% greater distance in sprints in the men's game). Major progress has been made in terms of physical performance in the women's game, although there is still a difference between the best players and the others.

RECOMMENDATIONS FOR PHYSICAL TRAINING

1. Basic and specific endurance (aerobic-anaerobic capacity)

- It is necessary to increase the aerobic base (aerobic capacity) but primarily specific endurance (aerobic strength) to improve the quality of play and changes of rhythm and promote better recovery.
- It is essential to work at an intensity of 85-90% of max HR (80% to 100% of MAS).
- This intensity has to be maintained both in terms of quality and quantity to achieve the expected results.
- Training of basic and specific endurance needs to be individual and adapted to the maximum aerobic speed (MAS) and heart rate of each player, notably through interval and intermittent training. Speed at the anaerobic threshold can also be used with the continuous method but essentially to develop basic endurance (aerobic capacity). This speed at the threshold is expressed at 20% less than MAS.
- The fartlek method (speed play) with changes in rhythm at maximum intensity and for the same time as in a match should be encouraged.
- With this in mind, alternating runs or dribbling the ball at different speeds with small-sized matches (3v. 3/4v.4), with an emphasis on metabolism, is a recognised method of aerobic training.
- The intermittent method is very well adapted to the match rhythm and should be prioritised to improve specific endurance (aerobic strength) from 85% to 100% of max HR and run at 90% to 120% of MAS.
- Formats such as 30-30", 15-15", 10-20", 5-5-20" or 5-25" with a duration of 5 to 9-10 minutes depending on the intensity produce excellent results. The recovery time can be used for a gentle jog or even low-intensity technical exercises.
- This method may also be practised in an integrated technical or technical-tactical form.
- For example, a player on the wing runs for 10 seconds with the ball and crosses precisely to an attacker who has run for a maximum of 5 seconds to meet the cross: these players have 20-25 seconds to regroup defensively before resuming the attack. This integrated technical work must always be focused on quality.
- Alternating continuous runs with changes of rhythm with and without the ball, aerobic coordination drills and intermittent exercises can all be used to good effect to train this area, as well as for general psychomotor development (coordination and motor skills).
- When doing endurance training with changes of rhythm and coordination and mobility (without and/or with the

ball), it is important that coordination (skipping, slalom, changes of direction, etc.) is trained in a reactive, dynamic or fast way, which also promotes the stimulation of the fast muscle fibres.

- Game play is of course a recognised method in training of the energy systems (aerobic and anaerobic), but requires the full commitment of the players and observation of the planned game duration. The playing surface is an important factor when deciding on the level of intensity of training.

2. Speed

- As with aerobic capacity, it is recommended that speed training be individualised, taking account of the player's position, and not necessarily based on running speed (which may vary from one player to the next) but on distances, the number of sprints and recovery time.
- In our analysis of the sprints at maximum speed, we observed a range of distances from 12m for certain players to 25m for attackers or wingers.
- Speed training should therefore follow this range of distances insofar as possible.
- Given that for speed purists the maximum and above-maximum speed can only be reached in separate sprints, speed training sessions can alternate between exercises without the ball (separate) and with the ball (integrated), start with only shots at goal or controlling the ball, but progressing to game play of a limited duration.
- The following aspects are very important in speed work, especially for women:
 - Firstly, optimise running training (footing, body position/ often keeping the backside low and working the arms, frequency of strides)
 - Secondly, increase the distance of maximum speed runs through acceleration and deceleration sprints and changes of direction (balance and landing strength) while also trying to improve anaerobic alactic potential
 - Thirdly, after a sprint, a gentle or moderate jog (depending on the distance of the sprint) back to the starting point can serve as the first phase of recovery, but more importantly to optimise the tactical mental aspect of defensive regrouping
 - ➔ This recommendation applies particularly to players in the formative phase.
- Fourthly, vary the running distances during the session or even in the same set (For example: set with 5 repetitions: 20m – 10m – 40m – 25m – 15m)
 - For these sprints, it is also fundamental to vary the types of run, changes in direction, moving angles, etc. This kind of variation enables players to do real sprints like in a match.
- When training speed off the mark, the focus should be on the positions and attitudes encountered in a match.
- (For example, a defender in a one-on-one defensive duel does not have the same position off the mark as an attacker moving off the mark for a counter-attack).
- Speed sessions should therefore be organised around stations for each position, with varying intensity, types of runs and exercises specific to the position. (e.g. attackers train in the attacking area with distances varying from 5m to 20m, wingers train on the wings with distances of 20m to 30m; central midfielders train getting away from markers with distances of 5m to 15m or even calls for long balls of 15m to 25m; full-backs work on the wings with speed off the mark (5m-10m) or acceleration speeds and changes of direction of 15m to 30m.
- During the speed session, after a warm-up focused on quality, it is essential to complete each repetition at maximum intensity while observing the recovery periods between repetitions and sets.
- To start with, to ensure quality and prevent injury, the first set in the speed training session could focus on running coordination (movement and running technique), allowing the player to prepare rather than starting immediately at maximum speed. As of the next set, maximum speed is required. (This approach is recommended particularly for young players).

3. Muscular strength

Although there is still some reticence regarding strength training for women (image of femininity, body shape, resemblance to men), a lot of progress has been made, although unfortunately not in all countries or among all players. In addition, for hormonal reasons (production of less testosterone, resulting in less muscle mass than men), women have less well-developed muscles. Nonetheless, in view of our analyses and the match performances, strength training needs to improve in

women's football, starting with young players, all the while taking account of the principles of individualisation and progression. Strength brings power, speed off the mark and self-confidence, promotes intramuscular and intermuscular coordination, and allows technique to be conditioned, thanks to better support, better balance and greater striking force. The physical athletic performances observed among some teams during Germany 2011 point to the considerable work undertaken in this area in certain countries to increase strength and speed.



- The first stage of training consists of strengthening the abdominal and dorsal muscles and the abdominal wall fixator muscles (strengthening the lower body and torso).
- This stabilisation of the upper body is important from an early age in young players, and is also essential for maintaining strength. It is recommended that this training is carried out daily. In parallel, the thigh muscles – essentially – and the legs are trained first with body weight and progressively with light weights and weights of 20% to 30-40%, with an emphasis on power.
- Speed-strength training is also used in the form of dynamic exercises (also braking to work on eccentric contraction). This allows the rapid muscle fibres to be trained very quickly, also using the dynamism and reactivity we need to teach these players.
- The plyometric method (multiple jumps) is recommended, with a progressive level of intensity (low, medium and high plyometrics), for girls who have a good level of coordination (running and jumping training) as it enables them to improve the quality of their training and helps prevent injury.
- Specific contrast training (heavy-light = with weights and transferring force into explosive jumps) can be used together with the combined method (strength-jumps-technique) for women players.
- This training should, however, only be introduced once the players have acquired a good level of inter- and intramuscular coordination and built solid foundations. This specific method is recognised in football and places the emphasis on strength and the neuromuscular system while working on technique.
- Specific plyometric strength training and combined training can be organised very easily on the field of play.
- Strength training to increase muscle mass may also possibly be considered for players, particularly those of formative age who individually need this type of strength.
- This type of training is recommended during periods of preparation, however, and only after progressively developing very good general strength (strength-

endurance and power) and with methodical supervision by the coach or physical trainer.

ANALYSIS SYSTEM

Tracking system

The Amisco system uses a sophisticated software algorithm to capture X, Y coordinates for every player and referee on the playing field. All objects are captured 25 times per second, which allows for virtual real-time tracking of player and referees. The Amisco system allows the XY positioning of each player to be tracked in live with a radius of 7cm at 96.5% accuracy, given minimum set-up constraints and an experienced operator.

Amisco consists of four tracking sensors and two back-up sensors. The system can be installed on a fixed location or as a mobile system on a tripod within the stadium on the match day. The system is optimally situated near the halfway line approximately 30 metres above field level. However, the system is flexible enough to be situated at a minimum height of 18 metres.

The operator identifies unidentified players in the tracking system. As with any live tracking system, all trajectories cannot be identified 100% and there might be small gaps in the trajectories. To help solve this problem, Amisco has added a plug-in that improves the Amisco data set. Based on many years of experience working with tracking data, this new system processed the data to be compatible with the post-produced data set with complete trajectories. This allows for a better real-time evaluation of performances based on averages from several databases (namely England's Premier League, Spain's La Liga, Germany's Bundesliga, France's Ligue Un, UEFA Champions League, etc.).

Quality control process

Once the match has started, the videos of the tracking cameras as well as the identification information from the

operator are transferred to a central production centre for quality control. During the match, the operator will correct/complete the tracking data. This control process can be done on-site as well. In the control process, we make the following three corrections

1. Link proper ID to player trajectories
2. Fill in the missing gaps in a player trajectory by manual tracking
3. Apply acceleration and deceleration control mechanism to have more correct high-intensity data

Figure 20:
Amisco tracking system

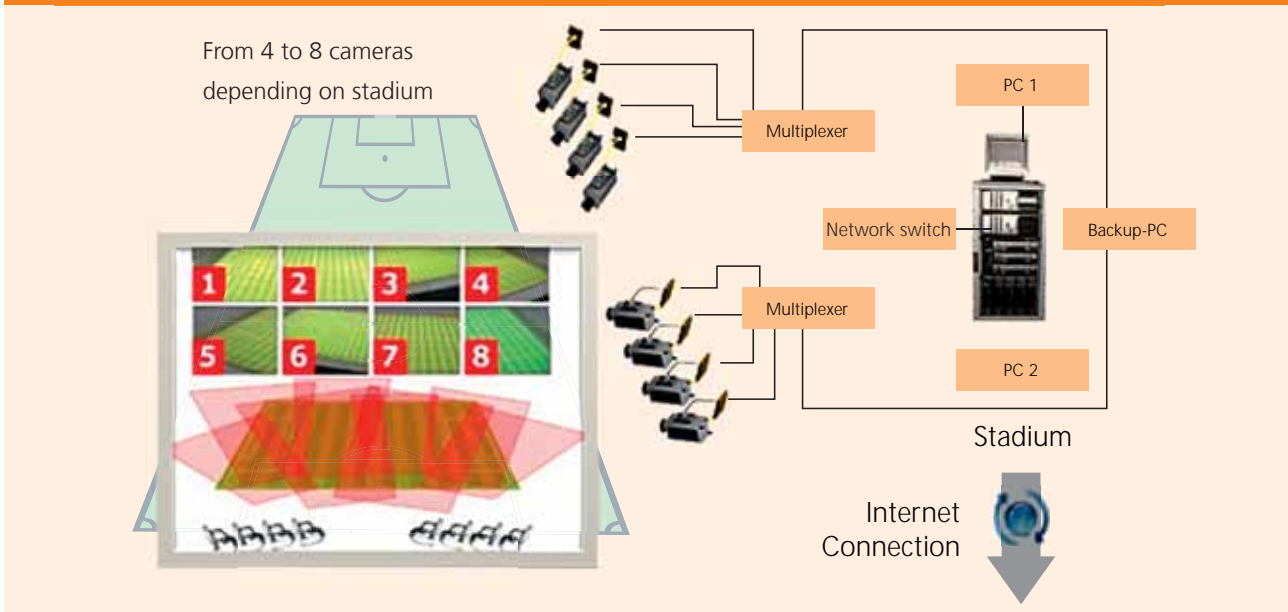
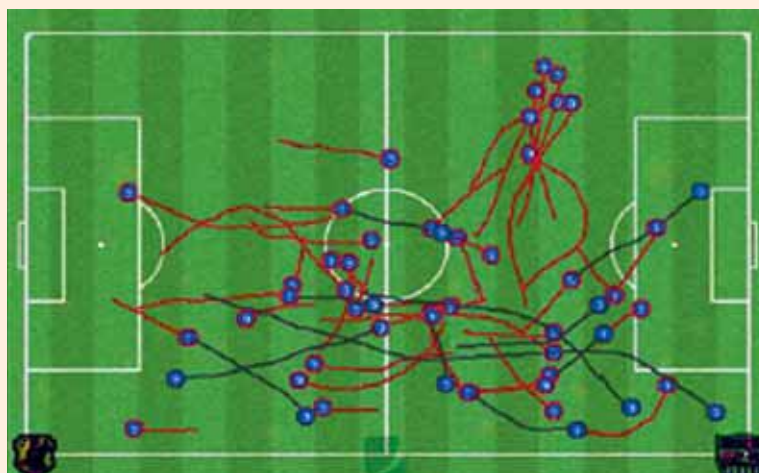


Figure 21:
Recording the runs and movement of one player during a match



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