Some biomechanical characteristics for sprint stride and its relation to foot placement on the curve and straight for 100 and 200 m sprinters

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Introduction

Nowadays, the world is heading to a rapid development in the sport performance, which calls for the comprehensive analysis of various performance requirements. Technology has contributed in this sport movement by promoting and developing the technical performance which become more clear and effective. In recent years, running has witnessed a new development which is crystal clear in breaking new world records, i.e. the legend usain boult (JAM) was able to break the world record in 100 and 200 m during the World Championship in Berlin 2009. There also shall be a need for more studies in all aspects of running force that generate the sprinting performance i.e internal and external potential energy, adaptation of the body to produce energy and effective force that is by developing fitness and technique.

Geng Lu, Darren, and Stefanyshyn (2013) find that when sprinters run along the curve, the inside leg reached its limit in generating limb force ; and by introducing additional mass, will leads to a significant increase in the ground reaction force and also increase its capacity to generate force (7: 4314)

Sarah M. Churchill, et al. (2011) show that maximam running performance decreases on the bend compared to the straight, which may be due to the changes in force productoin in the curve since the sprinter should, while running in the curve, generate suffient gravity force in order to follow the course of the curve and stay within their own lanes, which puts additional requirement of centripetal force generation compared to running in the striaght (12: 471)

P. Grimshaw, A. Burden (2007) noticed that while

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running in the curve on a flat track, runners lean in the curve causing lateral friction force, which is the source of the force of gravity. This lean continues until the runner reach angle O, where enough friction force is produced enabling the sprinter to rotate around the curve easily. This situation can be analyzed by considering the moments of preparation for the frictional force (F) and natural force (N) around center of mass (COM).

The free body diagram of an athlete rounding bend is shown in figure (1). As the athlete is balanced, the momnts about the center of mass (COM) are equal:

Equating moments N.x= F.y

Therefore F / N = x / y

Natural force N frictional force

Figure (5): free body diagram of an athl

Resolving vertically N-m.g = O (

The friction force is the source of the ce

(٣)

Combining (1), (2) and (3) gves

F/N= v² /r.g = tan O

Therefore O =tan-1(v²/r.g)

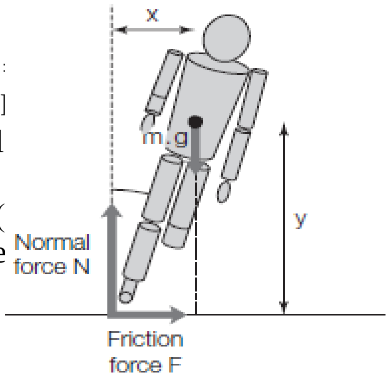

Fig. (1)

Athlete's lean angle in the curve, normal reaction force and frictional force

This equation allows the prediction of the angle of lean of a runner for any velocity, v, and cornering radius r. Typically for an athlete running at 10 m/s (a 200 m race) around an athletics track of radius of rotation 40 m, the angle of lean would be 14°. If the athlete performed on an indoor track of radius of rotation 20 m then the angle of lean would increase to 27°. (11: 175 176)

Research problem

The research problem is the ability of athlete to run with optimal technique in the curve compared to the straight because the requirements of force to overcome the centrifugal forces increase the time of touchdown at the moment of ground contact, in addition to the position and direction of the toe on the ground, whether inside or outside, which may have a relation with the optimal technique of the runner, especially lean movement of the athlete resulting in lateral friction force, which is the source of gravity. The lack of mastering the sprint stride in the curve compared to the straight may probably leads to increase running time and not to effectively employ the technique, that is what lead the author to identify the most important variables and differencies in sprint stride in the curve and straight, the nature of toe direction when running in the curve and straight.

Research objective:

Study the biomechanical characteristics and differences of sprint stride and its relation to toe position at touchdown in the curve and the straight to 100 and 200 m runners.

Research question:

− What are the biomechanical characteristics and differences of sprint stride and its relation to toe position on the ground in the curve and the straight to 100 and 200 m runners.

Research Procedures:

Methology :

The author used the descriptive method, based on the biomechanical analysis, using computer for its relevance to this study.

Subject athletes:

The subject athletes are two Egyptian records holder for 100 and 200m, who participed in the Senior National Athletics Championship.

Table (1)
Details about the athletes

Variables	Measement Unit	Amr Ibrahim		Ayman Mohammed	
Weight	Kg	٧٦		٨٣	
Height	Cm	١٧٩		١٨٦	
Chronological age	Years	٣٠		٣١	
Training age	Years	١٤		٨	
Personal best	Seconds	١٠,١٣	٢٠,٣٦	١٠,٤٥	٢١,٥٤

Table (1) shows the statistical description of the subject runners (height, weight, chronological age, training age and the personal best).

Prospective study :

The researcher conducts a prospective study on wednesday 1 october 2014 on the track of Zagazig University. The study included the following steps:

- The place was prepared for video recording by putting checkmarks (guidelines) in the background, range of motion and preparing the scale of drawing.

• The researcher used (2) Cameras of 125 c/s, and kinetic analysis system "Simi Motion". The cameras were installed on tripods. The author was keen to have the vertical axis of the camera's lens perpendicular to the sagittal plane.

• Cameras were placed 40 m from the starting line of the 200 m in the curve. One was placed 11 m from point 40m of the outer edge of lane (4) in the track at an angle of 90º. The second camera was placed 9 m from point 40m of the outer edge of lane (4) in the track, at an angle of 45º and 1.22 m height.

• Cameras were placed 40 m from the starting line of the 100 m straight. One was placed 9.5 m from the outer edge of lane (4) in the track at an angle of 90º. The second camera was placed 7 m from the outer edge of lane (4) in the track, at an angle of 45º and 1.19 m height.

• Markers were placed as checkmarks along the path of each camera according to the previous division, as well as markers along the start line and another along the finish line.

Basic study : -

The basic study was implemented on monday 10/11/2014 at 14:30 on the track of Zagazig University in the presence of a number of faculty staff. The author took into account all procedures of the prospective study.

Video recording stage:

Means of data collection:

TV imaging and analysis using computer tools.

- Two video cameras 125 c/s with electric battery was used, provided with lens to electronically regulate lighting. Calibration was done for both cameras.
- 2 Tripod for cameras
- chekmarks
- Drawing scale 20× 20 cm.

- Measuring tape to determine the dimensions of video recording.
- Digital watches to determine the required times.

The researcher has followed the following steps:
- Check the cameras before the start of the race.
- Ensure that there is no deviation or change in the cameras.
- The author was keen to have the lens vertical axis perpendicular to the spatial level at running in the curve and the straight of this study.
- Drawing scale was separately filmed for each camera before the start of the race. The camera len's range of motion was 7.5 m.

- Markers were placed at each 10 m from the start line.
- Each sprinter runs 3 times for 65 m in the curve and straight. The best time for each runner was chosen for analysis.

Discussion:

Presenting the results of biomechanical variables for subject runners at different times of sprint stride in the curve and straight:

Subject runners' results at touchdown (right support)

Table (2)
Subject runners' biomechanical variables at the curve and straight in the right front support (touchdown)

	Biomechanical variables	Amr Ibrahim		Ayman Mohammed	
		Curve	Straight	Curve	Straight
Right front support (touchdown)	1. Velocity of the COG (m/s)	٩,١٤	١٠,٩١	٩,٢٨	٩,٧٨
	2- Right toe transverse displacement to outside (cm)	٠,٧٠	٠,٥٧	٠,٩١	١,١٢
	3. Right knee joint height (cm)	٥٤	٥٦	٥٦	٥٨
	4. Left knee joint height (cm)	٥٩	٦١	٥٧	٦٢
	5. Momentum of the left arm (kgms/s)	١٢,٥	٣٠,٦	٦.٢٥	٧.٨٨
	6. Momentum of the left lead leg (kgms/s)[٢]	١٣.٧٨	١٦.٨٩	١٢.١٢	١١.٠٢
	7. Height of the COG (cm)	٩٧	٩٩	٩٦	١٠٢
	8. The horizontal distance between toe an COG (cm)	٣١	٢٩	٣٤	٣٧

Follow Table (2)
Subject runners' biomechanical variables at the curve and straight in the right front support (touchdown)

Biomechanical variables	Amr Ibrahim		Ayman Mohammed	
	Curve	Straight	Curve	Straight
9. Ground contact time from front touchdown to maximial inclination (s)	,٠٤٨	,٠٤٥	,٠٥٠	,٠٤٨
10. Angular velocity of the left knee joint (°/s)	٧٠١	٨٦٢	٦٥٨	٧٩٥
11. Left elbow joint angle (°)	١٠٨	٩٦	١١١	٩٩
12. Right support ankle joint angle (°)	١٣٤	١٣٠	١٣٦	١٣٧
13. Right support knee joint angle (°)	١٥٨	١٦٠	١٦٢	١٦٦

Table 2 shows the biomechanical variables of the right support phase (at the moment of touchdown) of the subject runners- the most important variables are: the velocity of COG (cm) – Right outside metatarsal transverse displacement (cm) and ground contact time (s).

Discussion of front right support (moment of touchdown) for subject runners

Results of Table (2) show the veloicty of the COG at the right leg touchdown for Amr Ibrahim in the curve was 9.14 m / s and Ayman Mohammed was 9.28 m/s, while the velocity of the COG raised in the straight which was for Amr Ibrahim to (10.91 m/s) and (9,785 m/s) for Ayman Mohammed. The velocity for the COG in the straight increased more than the curve due to the nature of the running in the curve where the force requirements to overcome the centrifugal force increased because of the inside lean of the runner, as the leaning motion caused lateral friction force addded to the force of gravity, placing additional required force on the sprinter.

The results in table (2) shows that outside transverse displacement of the right toe in the curve for Amr Ibrahim was 0.70 cm and 0.91 cm for

Ayman Mohammed while the outside transverse displacement of the right toe in the straight for Amr Ibrahim was 0.57 cm and 1.12 cm for Ayman Mohammed. In the author’s point of view, the toe is the smallest link to the ground and the’ metatarsal direction has a direct contact with the employment of force and technique. Since the right leg is the outside leg in the curve run, it is more contact with the stride length and the left leg fix the body and exert more effort than the right foot. Oleg nemtsev (2011) confirmed that sprinting around a bend, as in the 200m, forces the runner to contend with the task of maintaining high running velocity and at the same time counteracting the effects of centrifugal force. It is clear that the solution to such a task lies at least partially with the body part in direct contact with the ground: the foot. (88 ، 85 : 10).

Results show that right knee joint height in the curve was 54 cm for Amr Ibrahim and 56 cm for Ayman Mohammed, while the right knee joint height in the straight increased to 56 cm for Amr Ibrahim and 58 cm for Ayman Mohammed. The left knee joint height for Amr Ibrahim in the curve 59 cm and 57 cm for Ayman Mahammed, which increased in the straight to 61 cm for Amr Ibrahim and 62 cm for Ayman Mohammed. These results show differences in technical performance in the curve than the straight. The movement of the runner in the curve is around a radius, which forced him to inside lean which leads to some differnces i.e. COG. Table (2) show that the height of COG for Amr Ibrahim was 97 cm and 96 cm for Ayman Mohammed. The COG raised in the straight to 99 cm for Amr Ibrahim and 102 cm for Ayman Mohammed. The author belives that the horizontal distance between the foot placement and the COG affects the height of the COM, because the greater the horizontal distance between the foot placement and the COG, the lower the COG and vice verse as shown in table (2) that the horizonatal distance of the toe and COG in the curve was 37cm for Amr Ibrahim and 39 cm for Ayman Mohammed. The distance decreased in the straight to 29 cm for Amr Ibrahim and 35 cm for Ayman Mohammed.

Table (2) shows that momentum of the left leg for Amr Ibrahim (13.78) kg m/s^2 and for Ayman Mohammed (12.12) kg m/s^2. The momentum increased in the straight to (16 0.89) kg m/s2 for Amr Ibrahim and (11.02) kg m/s^2 for Ayman Mohammed. The momentum of the left leg increased in the straight more than the curve since

Momentum = mass × velocity

The velocity of the lead leg in the straight was greater than the curve since the momentum contribute in pushing the sprinter forward. The results show that the right ankle angle was 134° for Amr Ibrahim and 136° for Ayman Mohammed while it decreased in the straight to 103° for Amr Ibrahim and 137° for Ayman Mohammed. The right knee joint angle in the curve for Amr Ibrahim was 185° and 162° for Ayman Mohammed, while it increased in the straight to 162° for Amr Ibrahim and 166° for Ayman Mohammed. The results of table (2) show that ground contact time for Amr Ibrahim in the curve was 0.045 s (16.5%) 0.051s (17%) for Ayman Mohammed, while it decreased in the straight to 0.043 s (15.5%) and 0.047 s (16.5%) for Ayman Mohammed.

Results of propulsion

Table (3)

Biomechanical variables of the start and finish of acceleration for the subject runners at propulsion

	Biomechanical variables	**Amr Ibrahim**		**Ayman Mohammed**	
		Curve	**Straight**	**Curve**	**Straight**
Propulsion	1. Velocityfor COG (m/s)	٨.٧٥	٩.٢٠	٩.٥٢	٩.٩٨
	2. Height of the right knee (cm)	٥٦	٥٨	٥٤	٥٧
	3. Height of the left knee (cm)	٨٧	٩١	٨٨	٩٤
	4. Calculated speed of the left knee (m/s)	١٢.٩٨	١٣,٩٧	١٠.٧٥	١٢.٠٧

Follow Table (3)
Biomechanical variables of the start and finish of acceleration for the subject runners at propulsion

Biomechanical variables	Amr Ibrahim		Ayman Mohammed	
	Curve	Straight	Curve	Straight
5. Momentum of the left arm $(Kg/s)^2$	٦,٣١	٧,٩٦٨	٥,٦٢	٦.١١
6. Momentum of the left lead leg $(Kg/s)^2$	١٤,١٤	١٤,٨٩	١٣,١٢	١٣,٥٢
7. Height of the COG (cm)	١٠١	١٠٢	٩٨	١٠١
8. Horizontal distane between support toe and COM (cm)	٦٩	٧٣	٧٨	٨٢
9. propulsive time (s)	,٠٦٥	,٠٥٩	,٠٦٨	,٠٦١
10. Angular velocity of the right knee (lead leg) (°/s)	٩٨٧	١٣٨٣	٩٥٢	٩٩٠
11. Right elbow angle (°)	٨٥	٨٤	٨٣	٨٦
12. Right support ankle angle (°)	١٠٥	١٠٩	١٠٩	١٠٦
13. Right support knee joint angle (°)	١٥٤	١٥٨	١٦٣	١٦٩
14. Left lead leg knee joint angle (°)	٥١	٤٥	٥٥	٤٩
15. propulsion (newton/s)	٦.١٤	٦.٧٢	٧.٨٩	٨.٧٧
16. Stide length (m)	٢.٠٤	٢.٥١	٢.١٥	٢.٥٩

Table (3) shows the biomechanical variables of acceleration phase of subject runners in propulsion. The most important variables for the stride at this moment are – COG velocity (m/s), height of COG (cm) – angle between trunk and swing thigh (°)- momentum of the right lead leg ($kg\ m/s^2$)

Discussion of the Propulsion results

Results of table (3) show that velocity of the COG in the curve for Amr Ibrahim was (8.75 m/s) and for Ayman Mohammed (9.52 m/s). The velocity increased in the straight to (9.20 m/s) for Amr Ibrahim and (9.98 m/s) for Ayman Mohammed. The author believes that the runner at the propulsion moment increases the pushing distance by the effective range of motion of the hips, through exerting efforts for a long time in the correct direction, which in turn increase the pushing force generated by the pushing leg and increase running velocity. Results of table (3) show that the height of the right knee joint in the curve for Amr Ibrahim was 56 cm and 54 cm for Ayman Mohammed. It increased in the straight for Amr Ibrahim to 58 cm and for Ayman Mohammed 57 cm. The author believes that there is a relationship between the height of the support knee joint at the moment of propulsion with the height of the COG and horizontal distance between the toe of the support foot and COG and generation of horizontal and vertical velocity. The horizontal distance was 96 cm for Amr Ibrahim and 78 for Ayman Mohammed, which increased in the straight to 73 for Amr Ibrahim and 82 for Ayman Mohammed. These results shows that the horizontal distance increased in the straight than the curve, which affected the pushing force and stride length. The other factor was ankle angle of the support foot since the results of table (3) shows that the support right ankle joint was 105° for Amr Ibrahim and 109° for Ayman Mohammed, it increased in the straight to 109 ° for Amr Ibrahim and decreased for Ayman Mohammed to 106°. At the moment of propulsion, there is a change in the joint ankle through shifting from breaking to pushing in the stretch - shortening cycle (SSC), since the elastic energy is stored in the muscles, ligaments and tendons, then released to push the body forward by increasing velocity. Table (3) shows that right support joint angle was 154° for Amr Ibrahim and 163° for Ayman Mohammed, which raised in the straight to 158 ° for Amr Ibrahim and 169° for Ayman Mohammed. The left knee joint angle (lead leg) for Amr Ibrahim in the curve (51 °) and for Ayman Mohammed (55°), which decreased in the straight to (45°) for Amr

Ibrahim and (49°) for Ayman Mohammed.

Results show that impulse in the curve for Amr Ibrahim was 6.14 N/s and 7.89 N/s for Ayman Mohammed, which increased in the straight to 6.72 N/s for Amr Ibrahim and 8.77 N/s for Ayman Mohammed. These results shows that right leg exert more force in the straight than the curve, which in the opinion of the author, is related to the outside left leg in the curve and inside lean of the COM, it falls on the left leg, which expose the runner to more friction through the external force. The following are recommended at this moments: the velocity and angle of impulse, and COG height. Since the vertical force affects the runner and the ground,

Impulse = force × time

which change the momentum that rapidly move the runner forward. The results of table (3) show that time of propulsion for Amr Ibrahim was 0.065 s (22.5%) and 0.068 s (23.5%) for Ayman Mohammed, which decreased in the straight to 0.059 s (17%) and 0.054 s (18.7%) for Ayman Mohammed.

Results of the flight phase

Table (4)

Biomechanical variables of the start and finish of acceleration for the subject runners at flight phase

Biomechanical variables	**Amr Ibrahim**		**Ayman Mohammed**	
	Bend	**Straight**	**Bend**	**Straight**
1. Velocity of COG (m/s)	١٠.٧٣	١١.٣٥	٩.٤٢	١١.١٢
2. Flight time (s)	٠,١٢٤	٠,١٢٩	٠,١٣٣	٠,١٣٦
3. Left elbow joint angle (°)	٩٣	٨٩	٩٥	٩١
4. Right ankle joint angle (°)	١٢٦	١٣٤	١٣١	١٣٩
5. Right knee joint angle (°)	١١٥	١٣١	١١٢	١١٩
6. Angle between thighs at top arc of flight	٨٠	٨٥	٧٨	٨٩

Table (4) shows the biomechanical variables of acceleration for subject runners at the flight phase and the most important variables for the stride at this moment. Flight time (s) –angle between the thighs (°) - Flight time (s)

Results of the flight phase:

Table (4) shows that the velocity of the COM in the curve for Amr Ibrahim (10.73 m/s) and Ayman Mohammed (9.42 m/s). It increased in the straight to (11.35 m/s) for Amr Ibrahim and (11.12 m/s) for Ayman Mohammed. Flight time for Amr Ibrahim in the curve was (0.124 s) and for Ayman Mohammed (0.133 s) and increased in the straight to (0.129 s) for Amr Ibrahim and (0.136 s) for Ayman Mohammed. The author belives that the increase in flight time is due to the distance between support foot and COM at the moment of propulsion and the angle between trunk and thigh of the swing leg and the righ knee jont angle (swing). It is also affected by the runner's ability of full range of motion of ankle joint, knee, hips and the increase of the muscles resistance coefficient to expliot the elastic energy between the trunk and thigh of the lead leg. Since the stride total time is the total of flight time and support times, flight time for the Amr Ibrahim was 43% of the total stide time and in the straight 44.8% of the total stride time. In the curve, Ayman Mohammed was 46% of the stride total time and in the straight 47% of the stride total time. The flight time was higher in the straight than the curve which is reflected on the stride length. Results shows that thighs angle at the top arc of flight in the curve was 80° for Amr Ibrahim and 78° for Ayman Mohammed, which raised in the straight to 85° for Amr Ibrahim and 89° for Ayman Mohammed. The author belives that the more increase of the thighs angle at the top arc of flight (right angle), shoulders are parallel to the swing thigh, which contribute to increasing stride length (lead) leg became more active, which affects the ground contact time. According to Sarah M. Churchill (2012), the flight time of the right leg was (0.108) and left leg (0.118) during sprint. (121:11)

Results of left support moment (touchdown)

Table (٥)
Some biomechanical variables of sprint stride on the curve and straight for subject runners on the left forward support (moment of touchdown)

	Biomechanical variables	Amr Ibrahim		Ayman Mohammed	
		bend	Straight	bend	Straight
left forward support (moment of touchdown)	1. Velocity of the COG (m/s)	٨,٦٦	٩,٠١	٧,٤٧	٨,٨٩
	2.- Outside left toe transverse displacement (cm)	٠,٣٠	٠,٤٧	٠,٦٩	١,٢٠
	3. Left knee joint height (support leg) (cm)	٥١	٥٣	٥٢	٥٥
	4. Right knee joint height (lead leg) (cm)	٥٤	٥٨	٥٦	٥٩
	5. Momentum of the right arm (kgs/s)	٦,٤٦٢	٧,٠١١	٦.١٨٠	٦.٣٣٠
	6. Height of COG (cm)	٩٥	٩٦	٩٣	٩٥
	7. Horizontal distance between toes and COM (cm)	٣٧	٢٩	٣٩	٣٥
	8. Angular velocity of the right knee joint (º/s)	٦٨٩	٧٦٩	٦٥٧	٧٤٥
	9. Right elbow joint angle (º)	١٠٨	٩٩	١١١	٩٥
	10. Left ankle joint angle (º)	١١٨	١٢٠	١٢٧	١٢٩
	11. Left knee joint angle (degree)	١٤٩	١٥٦	١٥١	١٦٢
	12. Ground contact timefrom frontal plan to maximam lean (s)	٠,٠٥١	٠,٠٤٨	٠,٠٥٤	٠,٠٥٠
	13. stride length (m)	٢,٢٩	٢,٣٧	٢.٢٥	٢.٤٦
	14. 65 m time (s)	٧.٣٢	٦,٨٧	٧,٤٥	٧,١٢

Table (5) shows the biomechanical variables of the subject runners at the right forward support (moment of touchdown) and the most important variables for the stride at this moment, the calculated velocity of the COM $(m/s)^2$ - ground contact time (s) – stride length (m)-time of 65m (s).

Discussion of the results of the right support (touchdown)

Table (5) shows that the velocity of the COG in the curve for Amr Ibrahim was 8.66 m/s and for Ayman Mohamed 7.47 m/s, it increased in the the striaght to 9.01 m/s for Amr Ibrahim and 8.89 m/s for Ayman Mohammed. These results consistent with the study of Sarah M. Churchill (2011) which atated that the mean velocity of the right leg was 9.33 m/s and the left leg 9.39 m/s. Results of table (5) shows that the transverse displacement of the outside left toe for Amr Ibrahim was 0.30 cm and 0.69 cm for Ayman Mohammed, which increased in the straight to 0.47 cm for Amr Ibrahim and 1.20 cm for Ayman Mohammed. The results concluded that the outside direction of the right toe is greater in the curve than the left foot and there are general differnces in the position of the left and right foot which consist with Mohamed Soliman (2013), that there are differences between the left and right foot at the moment of touchdowm in some of the biomechanical variables: the horizontal distance between foot placement and COG, height of COG, ground contact time, and knee angular velocity. Results of table (5) indicate that the raise of the left knee joint for Amr Ibrahim was (51 cm) and (52 cm) for Ayman Mohammed, which increased in the straight to (53cm) for Amr Ibrahim and (55 cm) for Ayman Mohammed, while the height of left knee joint (lead leg) for Amr Ibrahim (54 cm) and (56 cm) for Ayman Mohammed, which increased in the straight to (58 cm) for Amr Ibrahim and (59 cm) for Ayman Mohammed. These results show that the height of the right knee joint in the curve is greater than the left knee joint, which is reflected om the height of the COG as shown on the results that the height of the COG for Amr Ibrahim in the curve was (95 cm) and (93 cm) for Ayman Mohammed, which increased in the straight to (96 cm) for Amr Ibrahim and (95 cm) for Ayman Mohammed. As shown in Table (5) the horizontal distance between the toe and COG was (37 cm) for Amr Ibrahim and (39 cm) for Ayman Mohammed, which decreased in the straight to (29cm) for Amr Ibrahim and

(35 cm) for Ayman Mohammed, as confirmed by Akira Ito, Koji Fukuda and Kota Kijima (2007) that the horizontal distance from the toe at landing to the center of gravity for the two sprinters was 0.31m. (٤٢: ٤).

The author noticed that the horizontal distance between the toe and the center of gravity at the touchdown are the most important variable that affects the velocity. The more increase in the distance, the greater the displacement of the center of gravity, which negatively affect the velocity. On the other hand, the shorter the distance, the lower the displacement of the COG, which positively affect the velocity. The toes should be up at the moment of touchdown, according to Loren Seagrave, Ralph Mouchbahani, and Kevin O'Donnell (2009).

The preparation for touchdown begins with the negative acceleration of the thigh. It should be emphasized that the runner who achieves high values of angular velocity by mechanical efficiency, not only depend on gravity to increase the velocity of the thigh. Results of table (5) shows that the angular velocity of the right knee joint in the curve was (689°/s) for Amr Ibrahim and (657°/s) for Ayman Mohammed. It increases in the straight to (769°/s) for Amr Ibrahim and (745°/s) for Ayman Mohammed. Sarah M. Churchill (2011) confirmed that the angular velocity of the left leg at touchdown was (853°/s), and the right leg (874°/s) during running in the curve. (12: 474). Table (5) shows that the ground contact time for Amr Ibrahim in the curve (051.0 s) (17.5%) and 054,0s (18, 7%) for Ayman Mohammed. It decreased in the straight to 0.048 m (16.5%) for Amr Ibrahim and 050.0s (17%) for Ayman Mohammed. According to Young-Hui Chang and Rodger Kram (2007), inside leg with limited ability to generate force during the pushoff due to the increased in the vertical and lateral force in the curve causing an increase in contact time for this foot. (14: 971)

The results show that the stride length in the curve for Amr Ibrahim was (2.29 m), and Ayman Mohammed (2.25 m). It increased in the straight to (2.37 m) for Amr Ibrahim and (2.46 m) for Ayman Mohammed. The results indicate that the time for 65m was 7.23 for Amr Ibrahim in the curve and 7.45s for Ayman Mohammed. The stide length decreased in the straight to (6.87 s) for Amr Ibrahim and (7.12 s) for Ayman Mohammed. The results also show that an increase in the total running time for 65 m in the curve than the straight, which reflected in the velocity index that was higher in the straight than the curve.

Conclusion and Recommendations:

-Conclusions:

Given the results of the biomechanical analysis of this study as well as the subject athletes, the author has reached to the following conclusion:

- The Egyptian sprinters put the right foot in the curve outside the transverse displacement of the right toe for Amr Ibrahim in the curve (0.70 cm) and Ayman Mohammed (0.91 cm), while the outside transverse displacement of the right metatarsa toe for Amr Ibrahim in the striaght (0.57 cm) and Ayman Mohammed (1.12 cm).
- Ground contact time of the right foot decreased more in the straight than the curve at the moment of touchdown (right support) the ground contact time for Amr Ibrahim in the curve was 0.045 s (16.5%) of the total time of the stride while Ayman Mohammed was 0.051s (17 %) and decreases in the straight as it was 0.043 for Amr Ibrahim (15.5%) and Ayman Mohammed was 0.047 (16.5%) of the total time of the stride.
- Increase of the flight time in the straight more than the bend, since the flight time for Amr Ibrahim in curve was 43% of the total time of the stride and in the striaght 44.8%. For Ayman Mohammed it was 46% in the curve and 47 % in the straight which was reflected on the stride length.
- The stride length increased in the straight more than the curve, it was for Amr Ibrahim 2.29 m in the curve and for Ayman Mohammed 2.25 m. The stride lenght increased in the straight, for Amr Ibrahim was 2.37 m and Ayman Mohammed was 2:46 m.

-Recommendations:

Given the results of the biomechanical analysis of this study as well as the subject athletes, the author has made the following recommendations:-

1. The need to focus on the outside foot position in the curve (external) and phalanges during sprint in the bend.
2. Using the sprint training that help to development the bend technique by running in different lanes (from lane 1 to 8).
3. Using running technique training in the bend and straight in various distances.
4. Taking into account the quantitative values of the biomechanical variables in various mements of sprint stride shown by this research.
5. Further studies on the nature of the running in different lanes on the curve.

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