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BIOMECHANIST AS AN ADISOR TO RUNNERS

A paper describes possible advisory activities of biomechanics specialists to the coaches and competitors. These activities can include problems of talent identifica-tion, training problems, technique and tactics, diagnosis of competitors, activities during competition, as well as refereeing. Examples of common problems are given and then some consultations to long distance runners, sprinters, hurdlers and stee-plechase runners. There are no ideal runners. There are no masters that can't be improved.

Key words: *biomechanics of sport, long distance runs, sprints, hurdles, steeple-chase.*

1. INTRODUCTION

Biomechanics is a science that is based on several other sciences, namely: biology, especially anatomy and anthropology, health sciences, biomaterials, mechanics, metrology. Main areas of biomechanics are: object morphology, function and control, equilibrium and movement of an object, environment. It can be applied to ergonomics, engineering, sport, medicine and many other areas [Erdmann 2015].

Biomechanics plays an important role in several human activities. It helps to understand interaction of a human body and tools and equipment, human body and mechanisms and machines, human body and surrounding both inanimate and animate.

Biomechanist works through deduction and through induction. The first one is based on scientific thoughts that are obtained from scientists' knowledge, experience, skills. The second is based on observation, recording, measuring. Biomechanist identifies the natural problems, connections between them and influence of one problem on another. He also sets several special experiments, both at the laboratory and in the field. The knowledge he acquires from his/her scientific data can be used for formulation of scientific formulas, theses, laws [Erdmann 2009].

2. BIOMECHANICS OF SPORT

There are a lot of possible applications of biomechanics within a sport. Within the running there are especially [Erdmann and Grubecki 1995, Erdmann 2008]:

1) Talent identification. Here special sportspeople can be added to specific sport discipline. Sportsperson's morphology, function and control is taken into account [Erdmann 2007].

2) Training. It starts with a movement-up (a warm-up). All muscle groups should be activated starting with distal joints. At first singular body parts, then groups of parts, then the whole body. At first without additional load then with a load. Also at first with small velocities then with higher velocities. Training takes into account different exercises, their amount and time of activity.

One of the most important problems is load that has to be overcome. The load could be mass and moment of inertia (mass times the squared distance of the mass according to the axis of rotation) of own body or of the objects moved (e.g. a barbell). Another load is a gravity force. Still another load is resistance of an air, water, snow, a partner or a coach. It is very important that a coach should teach competitors how to overcome a load in order not to acquire injuries and not to be overloaded.

3) Technique. This is a manner a competitor moves his own body or other bodies (a partner or an equipment). Kinematics data like location according to the reference objects, displacement, velocity, acceleration, both transversal and rotational are taken into account. Then kinetics data like forces, moments of force, momentum, work, power are calculated.

4) Tactics. It is very important what distribution of effort would apply a competitor within sport activity. This can be described using the data of e.g. velocity distribution along the whole distance. Unfortunately, some runners run too fast at the beginning of a long distance run. Others (like Usain Bolt in sprint run) are happy with the winning and they do not care about the best time of the run [Bolt and Allen 2013]. They slow down just before the finish line. There are other examples of sprinters, like Valeriy Borzov (Fig. 1) and Michael Johnson, who fought to the very end of a run [Petrovskiy 1978, Johnson 2016].

5) Diagnosis. During the training, especially before competition, and then during the competition sportspersons should be diagnosed. This concerns muscle strength in: a) absolute values, b) according to body mass, c) explosive strength (as strong as possible and as fast as possible), d) endurance strength (interval and continued). This concerns also possibility of movement in joints, global movement, e.g. during power exercises (vertical jumps), analysis of technique and tactics. The letter should be checked under the pressure of

environmental odds, e.g. shouting spectators. It is very important to make diagnosis also during a competition since competitors input all their effort in order to have the best performance (Fig. 2).

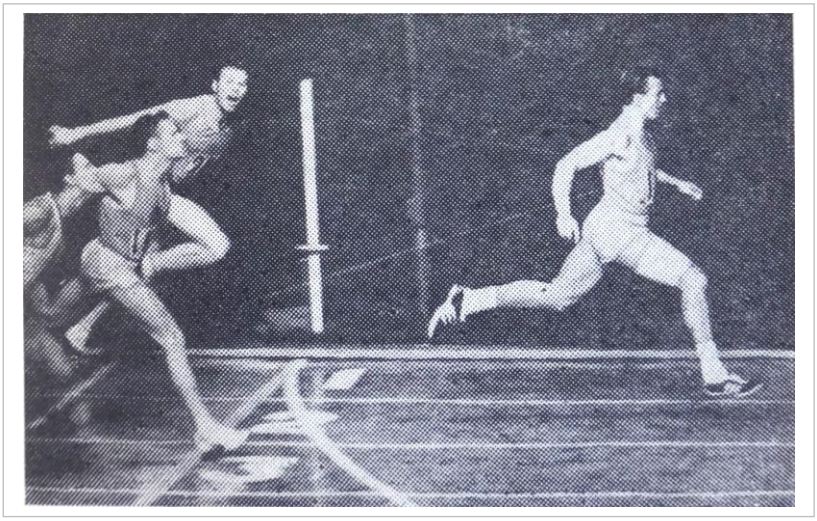

Figure. 1. Valeriy Borzov runs intensively to the very end [photo from: Petrovskiy 1978]

6) Competition. Depending on a stage of competition a competitor's effort changes. During heats the last fragment of a run can be covered with smaller velocity if a runner is sure he/she would qualify to the next round. In the finals competi-tors run as fast as possible. If there is a possibility of breaking a record competitors fight to the very end. For viewers at the stadium and before television sets at home organizers use photocells established at the finish line. Time of running while crossing the finish line is on-line showed at the stadium's television screen. Also virtual lines are shown during throws and during horizontal jumps in order to realize at once the quality of performance.

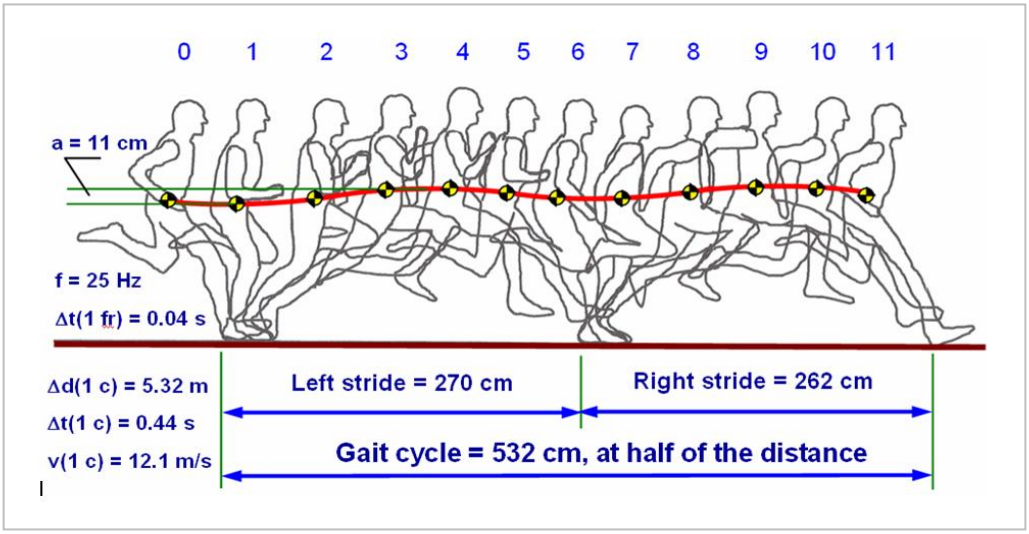

Figure 2. Cinegram of Usain Bolt (Berlin 2009) during world record run 9:58 s [Erdmann 2016]

7) Refereeing. The first approach to refereeing of running was based on observation. Then mechanical and next electric and electronic sport watches were introduced. During Stockholm Olympic Games (1912) a photograph was used in order to establish positions at the finish line. In 1932 a photo finish camera was applied. Here at the finish line a photographic film was moving from one reel onto another. Through a gap of 0.2 mm all what happened at the finish line was recorded. Today it is done using photo-elements or high speed video and recorded data (with a frequency of 2000 Hz) are stored in the computer [Bovay 1988].

Another device is a transponder system. During marathon run a competitor holds a small personal chip on a shoe and below the track is laid down a sensor. At every 5 km of a distance and at the finish line the personal time is recorded. During stadium run a competitor has a small chip attached to the bib number. Data from that chip are radio transmitted to the control box and then to the referee's computer.

Also activity of competitors on the start blocks is controlled. A sprint runner can't push at the block with a force greater than 25 kG earlier than 100 ms after the starting signal. Yet another device is used for measuring wind velocity. In order to establish a new record wind velocity can't be higher than 2.0 m/s aiming at the same direction as the runner's movement [IAAF 2015].

3. BIOMECHANIST AS AN ADVISOR TO DIFFERENT RUNNERS

3.1. **COMMOMN PROBLEMS**. First of all a technique problem should be presented. Here movement in joints can be analyzed, leaning of the trunk, length of strides, frequency of strides, velocity of movement [Erdmann 2008].

3.2. **LONG DISTANCE RUNNERS.** Beyond the technique the most important in running is kinematics of tactics. This should be understood as a distribution of velocity along the whole track of the run. The best runners in the world usually run with substantial value of velocity at the beginning, then they slow down a little and at the end they accelerate their movement. Overall approach shows they run the second half of the distance faster than the first one. But thousands of other people run in reverse. They run at the beginning with too high velocity and then they slow down finishing with much lower velocity [Erdmann and Lipinska 2013] – Fig. 3.

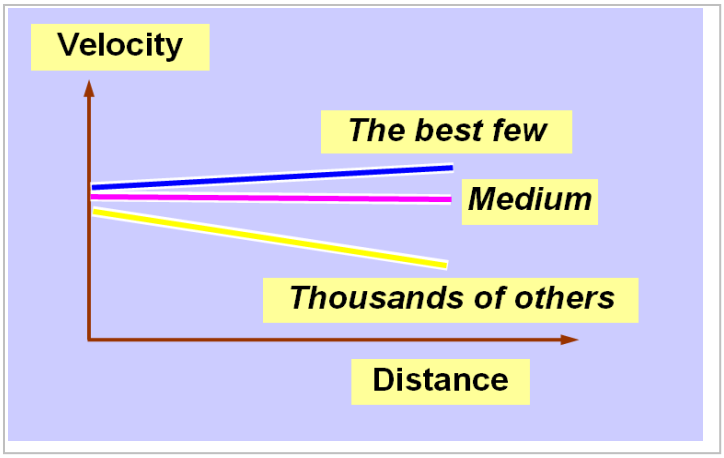

Figure 3. Trends of velocity distribution of long distance runners [Erdmann 2016]

3.3. **SPRINT RUNNERS**. There is very important part of running is the start, i.e. short reaction time (but it is not necessary to have very short reaction time) and then to have very good drive interval. Then the biggest problem in sprint running is to maintain high velocity. There is a substantial change in sprint running comparing end of the 20th century and beginning of the 21st century. Runners like Usain Bolt, Tyson Gay, Asafa Powell running 100 m distance can maintain their high velocity almost up to the very end of the run (Fig. 4).

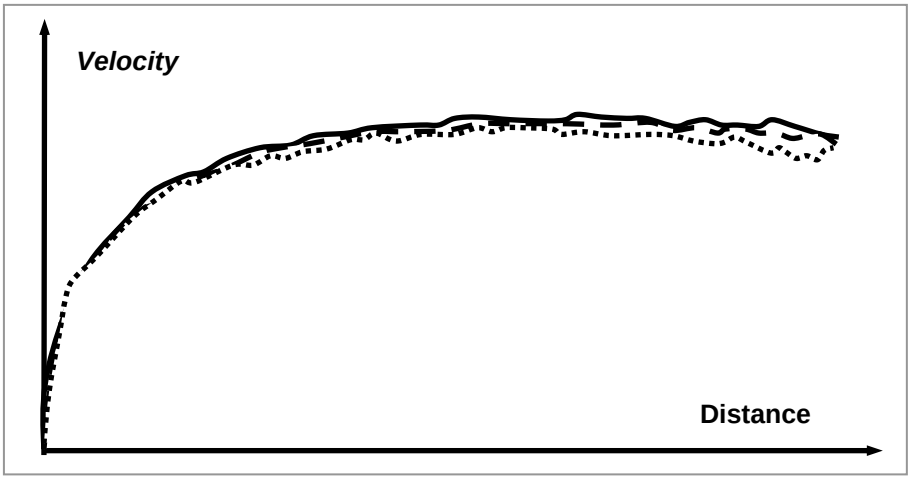

Figure 4. Comparison of smoothed velocity curves for the best runners in Berlin 2009 final 100 m run: Usain Bolt (solid line), Tyson Gay (dashed lone), Asafa Powell (dotted line). Bolt had the best drive and acceleration intervals and maintained higher velocity almost to the very end comparing to Gay and Powell (based on a Figures presented by Graubner & Nixdorf, 2011)

Unfortunately during the runs for 200 and 400 m runners obtain high velocity during the second section of a run (second 50 m during 200 m and second 100 m during 400 m) and then they slow down running considerably. This is not a good practice. This run is not to obtain the highest instantaneous or the highest segmental velocity. Here the highest mean velocity for the entire distance should be obtained. From the biomechanical point of view higher velocity gives higher air resistance, so it is not good to have high difference between the highest and the lowest values of velocity – Fig. 5.

Some runners, like Usain Bolt run with too wide movements in a frontal plane. They spend energy on not necessary movement [Erdmann 2016] – Fig. 6.

Still another problem is that runners run wearing too loose shirts or they have long, dispersed hair – Fig. 7.

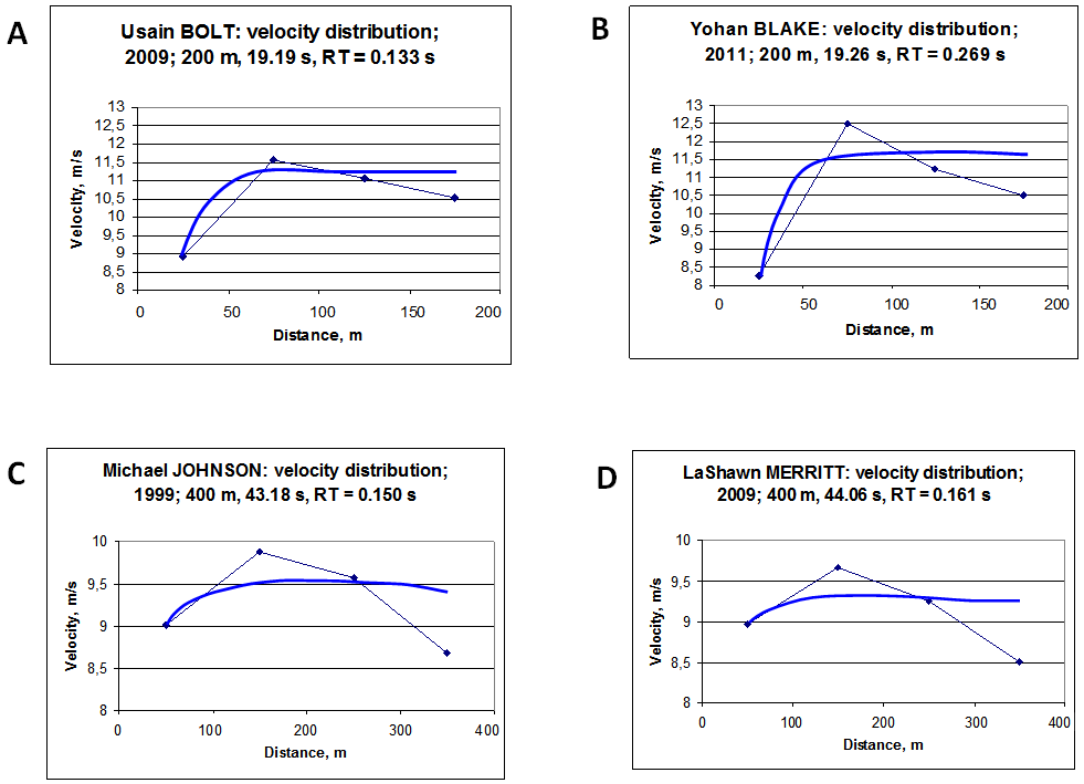

Figure 5. Bolt's (A) and Blake's (B) velocity diagrams for 200m; Johnson's (C) and Merritt's (D) velocity diagrams for 400m m. Thicker lines indicate proposed positive distribution of velocity [Raw data from: A and D – Graubner and Nixdorf 2011; B – águias-sports.blogspot.com 2011; C – youtube.com 2016]

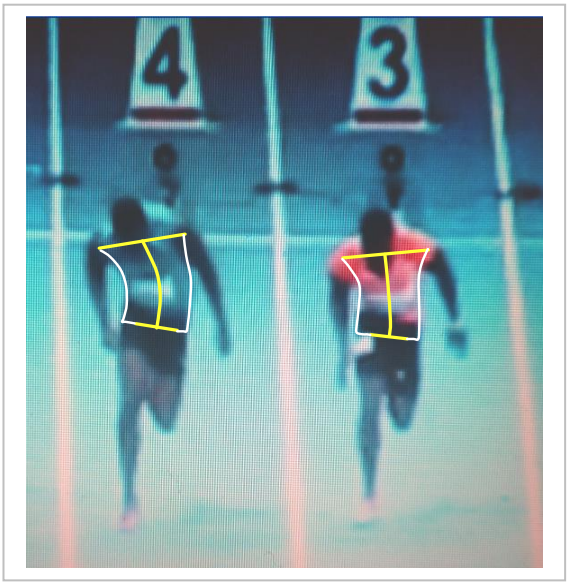

Figure 6. Movement to the side of Usain Bolt (at left) [Erdmann 2016]

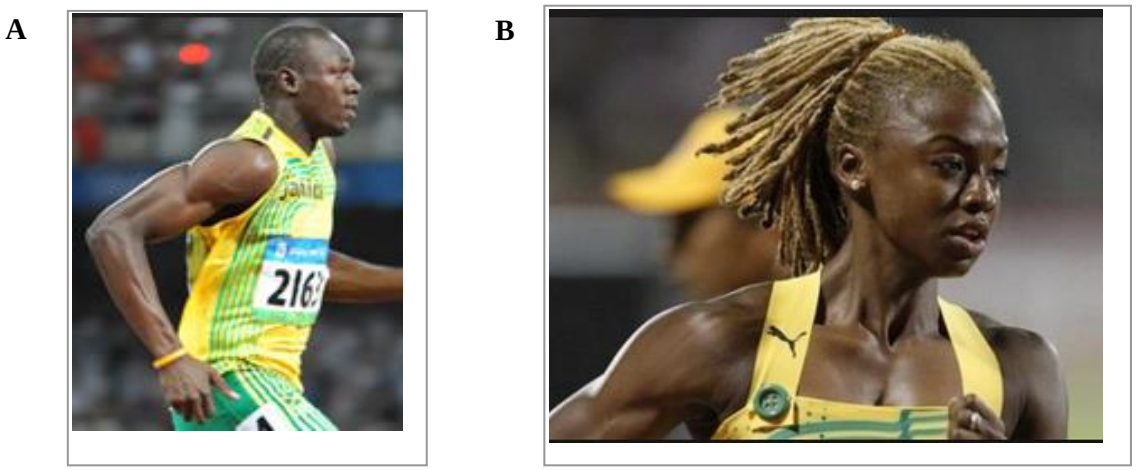

Figure 7. Loose shirt (A) and long hair (B) are not good shapes in diminishing air resistance (photos: hotreadsports.com and fansshare.com)

3.4. **HURDLERS AND STEEPLECHASE RUNNERS.** Running the run with obstacles needs very good technique of clearing the obstacles. There should be very high velocity when moving lower leg during attacking a hurdle, high leaning of the trunk, and then after passing the hurdle it should be done a high velocity movement of the entire lower extremity in order to touch the ground and to propel the body. This technique would give a center of mass trajectory as close as possible to the upper edge of the hurdle without touching it. Unfortunately, beginners make substantial errors while clearing the obstacles (Fig. 8).

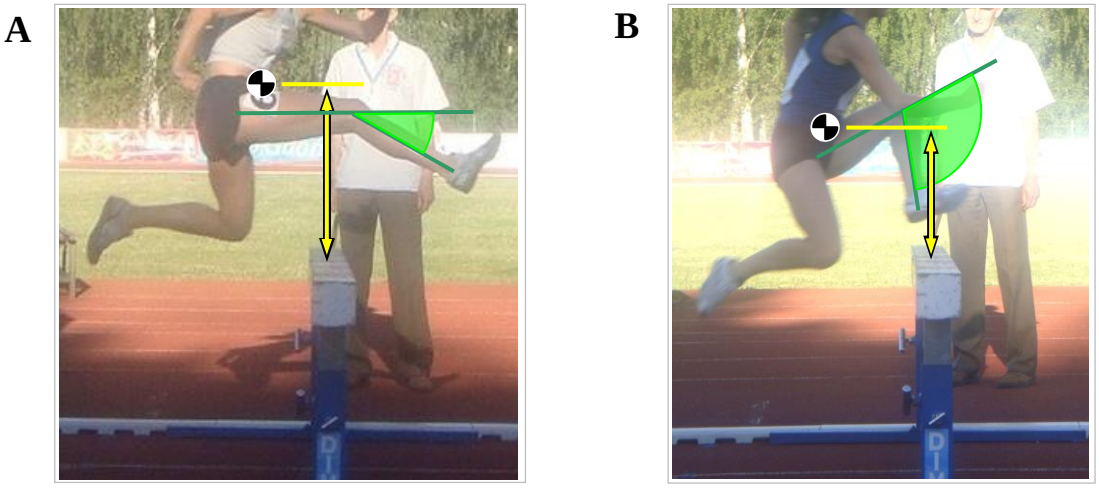

Figure 8. Clearing an obstacle by novice runners: A – with too high flight; B – with not straighten lower extremity

4. CONCLUSIONS. There are very good runners in the world. They achieve very good results. But they can run even better if they would obey biomechanical principles. There are no ideal runners. There are no masters that can't be improved. Some people put the question – was it possible for Usain Bolt to run faster. The answer is: yes, of course he could run faster if he would apply some biomechanical advices. He is very tall, his muscles are attached to the bones further from the hip axis. This is an advantage, because his muscles work with more efficient lever. Usually, the longer legs, the higher inertia to overcome. But not in the case of Usain Bolt. His body is slim, so his lower extremity muscles (especially iliopsoas) have not so high load to overcome. His

technique of upper extremities can be improved, i.e. range of movement in the arm joints. He moves upper extremities with too small range especially at the second half of a running distance.

Every runner should be checked during diagnostic procedures by biomechanist in order to find out weak characteristics of fitness preparation, technique and tactics of movement.

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Ердман В.

**ФАХІВЦІ З БІОМЕХАНІКИ
ЯК ПОРАДНИКИ ДЛЯ СПОРТСМЕНІВ-БУГІНІВ**

У статті описується можливість консультативної діяльності фахівців з біомеханіки для тренерів і спортсменів. Ці заходи можуть включати проблеми виявлення талантів, проблеми підготовки, удосконалення техніки і тактики, діагностики конкурентів, діяльності під час змагань та проблеми суддівства. Наведено приклади типових завдань і надано деякі поради бігунам на довгі дистанції, спринтерам, бар'єристам, бігунам з перешкодами.

Ключові слова: *біомеханіка спорту, біг на довгі дистанції, спринт, біг з бар'єрами, стіпль-чейз.*

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