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BIOMECHANICAL RESEARCH OF SPORT LOCOMOTION TACTICS IN GDANSK

Gdansk sport researchers are involved in several projects with the aim of improving participating in sport competitions from the point of view of tactics during locomotion in: sport games, alpine skiing, athletic running and walking and other disciplines. Obtained results were transferred to coaches and sportspersons.

Keywords: *biomechanical research, sport locomotion, tactics, Gdansk*

1. LOCOMOTION

Locomotion is one of the main forms of human movement. A word "locomotion" was derived from *Latin*, and means *locus* – a place and *motus* – a movement. A word locomotion was included within the English language dictionary already 350 years ago.

Locomotion is a change of location of an object according to acquired reference system. This system can be the nearest other stationary or moving object, the ground, other further objects. For example, in soccer it could be: a goal, a ball, partners, opponents, pitch and its lines.

There are many forms of locomotion according to [Erdmann 1998]:

1. Propelling forces: human, natural (physical and biological), anthropogenic.
2. Environment: land (on the surface and underground), water (on and below water surface), air (near and far from the ground), cosmos (parabolic flights, orbiting the Earth, beyond the Earth).
3. Number of participating objects: individually, in two, in a small group, in a large group, in a crowd.
4. Kind of objects: freely, with mechanisms (e.g. a bicycle, a kayak), with machines (e.g. a car, an airplane), with animals.
5. Technique and tactics of movement: monolithic (e.g. rowing crew), dependent (e.g. dance group or soldiers during parade), connected (e.g. himalaists joined with a rope), loose (e.g. players of sport games with individual techniques but with common tactics to win).
6. Personal equipment: natural (without equipment), with endings (boots, skates, skis), in uniforms (firefighter, hockey goalkeeper).

Locomotion changes also according to: onthogenesis, load conditions, in different psychological and sociological conditions, health status, medical problems.

2. TACTICS. Tactics means a manner of action which gives accomplishment of the aim. It is executed usually according to acquired plan. Sport tactics takes into account all possibilities and forms of sport competition and utilization of them against an opponent in given circumstances. This is also a manner of action of sport fight, which takes into account sport regulations, own and opponent's skills, sport arena and conditions.

There are sport tactics: 1) individual, 2) formation, 3) team. Individual tactics takes into account mental level of a sportsperson, its body build, fitness level. Formation tactics refers, e.g., to attacking or defending groups of players. Team tactics takes into account, e.g., winning action or defeating with the possible smallest difference of points. Tactics depends also on the level of competition and stage of competition.

3. BIOMECHANICAL APPROACH TO SPORT TACTICS. Main areas of interest within biomechanics of sport for many years were: mechanics of body build, muscle mechanics, technique of movement, influence of equipment and environment on movement.

Since about 30 years some researchers devoted their work also to biomechanics of sport tactics. In the mid-1980s there were two monographs published on sport tactics: Utkin [1984] presented biomechanical aspects of sport tactics and Pruski [1984] presented mathematical and computerized optimization of tactics.

There are several aspects of biomechanical approach to sport tactics [Erdmann 2007]: 1) inclusion of sport candidates to the sport discipline, taking into account their mechanical body build, basic fitness based on mechanical quantities, possibilities of cybernetic level of control; 2) selection of sportspersons, i.e. inclusion to the team actually the best players or members of a crew; 3) investigation of equilibrium, e.g. in shooting, archery, sport acrobatics; 4) investigation of a movement, especially locomotion, i.e. what positions should maintain bicycle riders according to the wind, which track chooses a sportsperson (e.g. in alpine skiing), the best distribution of velocity during the whole competition (especially in long distance running, skating, cross country skiing).

4. EXAMPLES OF RESEARCH ON SPORT LOCOMOTION TACTICS IN GDANSK

4.1. INTRODUCTION. In 1987 Gdansk team of sport biomechanists under the leadership of Erdmann started a long time research activity devoted to sport tactics. This activity is still present. There were about

30 co-workers who performed several scientific works on many sport disciplines, especially on: sport games (team handball, soccer, basketball, field hockey, ice hockey, volleyball), alpine and cross country skiing, athletics (short and long distance running, race walking), rowing, swimming, speed skating.

All biomechanical sport tactics investigations were performed on data gathered during the highest level competitions, namely: Olympic Games, World Championships, World Cups. These data were collected personally by the teams of researchers during above competitions or were collected by utilization of data presented by the organizers of a competitions on the web sites.

4.2. SPORT GAMES. Within the sport games movement of players differs. But all what they are doing in the pitch is devoted to one acquired tactics. It is possible to record position of all players, at every location, during every second of the competition's time. Movement is presented using mechanical data of: displacement, time, velocity, acceleration – of individual player, formation, the whole team.

Figure 1 presents localization of a video camera with wide-angle lens in order to have in the camera's viewfinder the image of the whole pitch [Erdmann 1987].

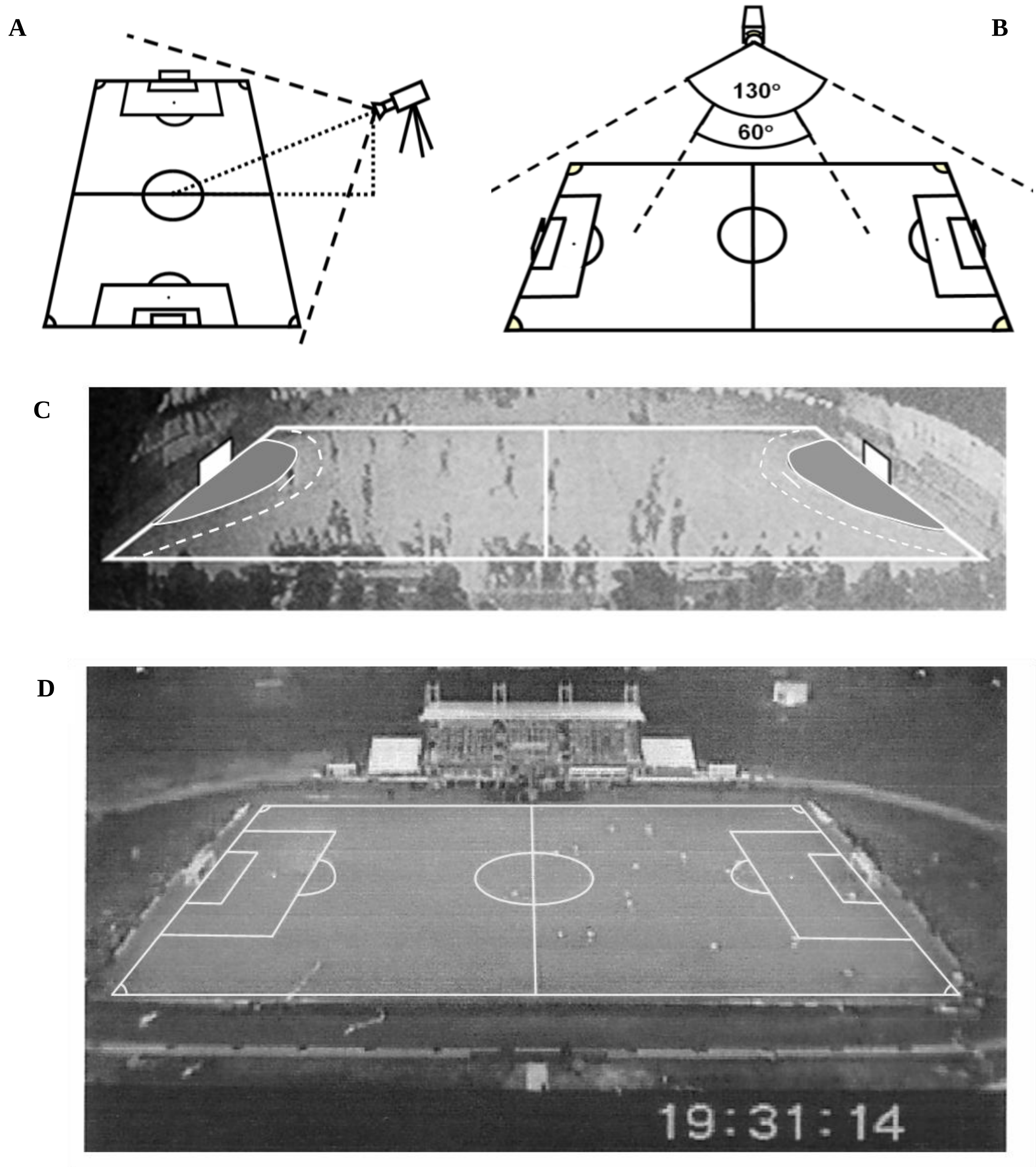


Figure 1. Investigation of sport games' tactics: A, B – location of the video camera above and in a distance to the pitch, equipped with wide-angle lens, C – image of a team handball pitch, D – image of a soccer pitch.

During the team handball match players cover about 4 to 5 km of the distance [Czerwinski 1990], while during the soccer match they cover 9 to 12 km Some of them cover even up to 14 km. Usually during second half of a match they cover more of a distance. Every player has its own area of action (Fig. 2A). Much of the time players stay or walk. But attackers sometimes run with a high velocity – up to about 9 m/s (Fig. 2B) [Dargiewicz 2005].

The point representing the whole team shows the area where the team attacks (Fig. 2C). For the whole match this point shows also which team was more offensive and which was more defensive (Fig. 2D).

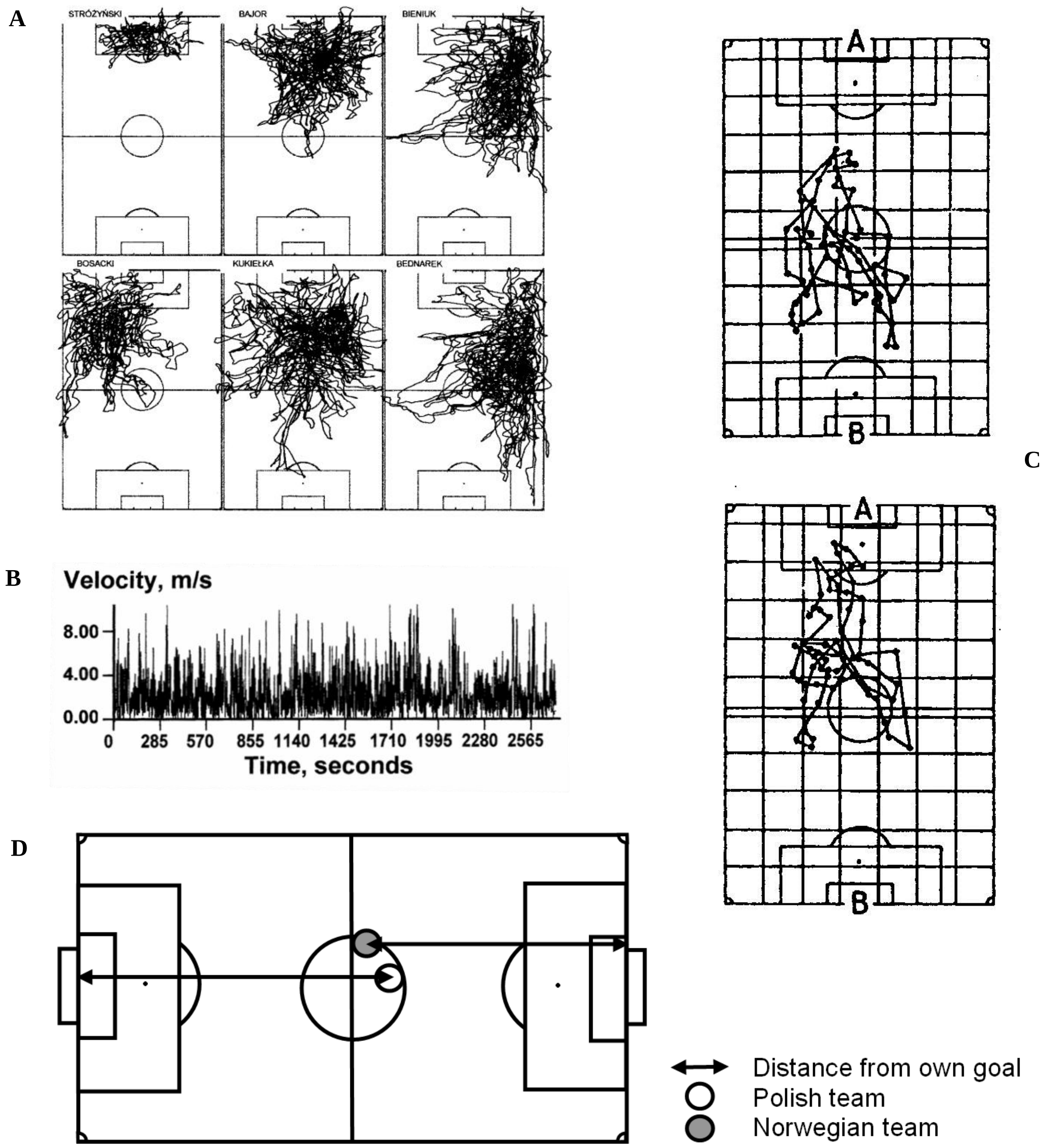


Figure 2. Some results of analyses of soccer matches: A – displacement of players at different positions, B – instantaneous velocity of one player during the first half of a match, C – within 5 minutes of a match team A attacked twice at the sides while team B attacked twice in the center of a pitch (locations showed in 5 s intervals) , D – locations of the teams for the whole match; the Polish team (mean velocity 1.9 m/s) was more offensive comparing to the Norwegian team (mean velocity 1.7 m/s); Polish team won 2:1.

4.3. ALPINE SKIING. Skiing in a competitive way appeared in Norway. Later on it moved to Alps where on the stepper slopes downhill and slalom disciplines were practiced. Now there are four main sport disciplines within alpine skiing, namely: slalom (SL), giant slalom (GS), super giant (SG), downhill (DH). These disciplines are present during Olympic Games. There are also championships and world and continental cups.

Investigation of alpine skiers' tactic of running in detailed form started in Greece where Erdmann and Giovanis [1997] measured distances between gates, and also angles of inclination and deviation of intergate distances at the whole course. Then Erdmann and Aschenbrenner accomplished investigations of the best world skiers during several FIS World Cup competitions in 5 European countries: AUT, GER, ITA, NOR, SLO – Fig. 3.

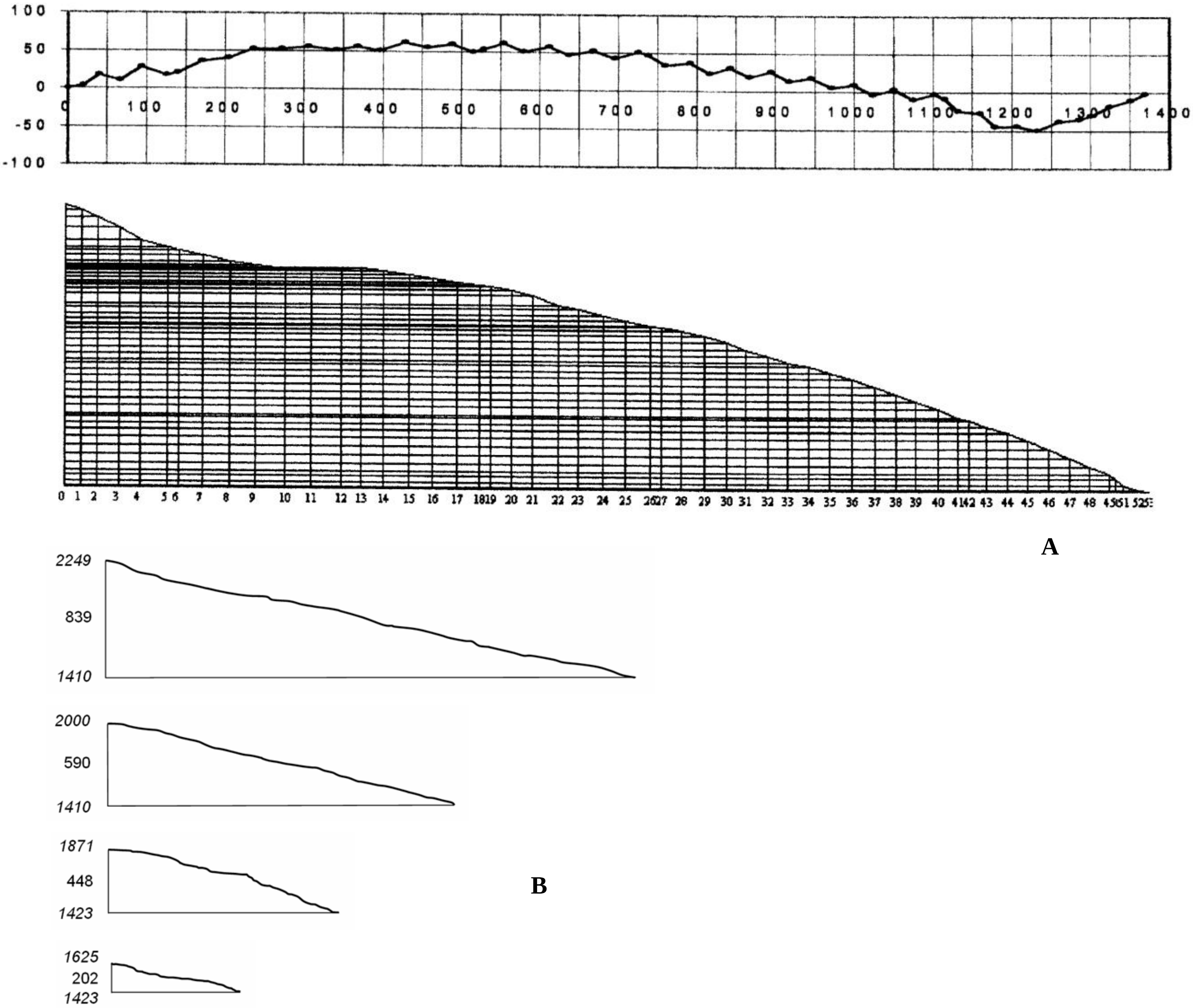


Figure 3. Examples of geometry of alpine skiing courses: A – view from the top and from the side of giant slalom in Saalbach (AUT) in 1998; B – comparison of general view of four disciplines, namely from the top: DH, SG (Val Gardena, ITA), GS, SL (Alta Badia, ITA) in 2006; vertical distances in m above the sea level.

Detailed investigations of alpine skiing running revealed those skiers who are within the group of first 10 places after about 1/4 of a distance are not within the group of first 10 places at the finish. They run too intensive with high accelerations and decelerations. Then they are too much fatigue and drop to the further places. It pays to run the first fragments of the course with medium velocity in order to run further with higher velocity and thus the entire course with shorter time. Also in some fragments of the course the best 10 finishers ran slower then other skiers in order to run further fragment with higher velocity and in shorter overall time [Giovanis 1998, Aschenbrenner 2002].

4.4. LONG DISTANCE RUNNING. Long distance running, i.e. 5, 10, 42.195 (marathon) km and longer distances, are very demanding sport activities. Here not technique of running but tactics of running plays more important role. If somebody does not control distribution of effort, especially when the run takes play during a hot weather, then very dangerous situation arises. According to Matthew et al. [2012] only in the United States during the period 2000-2009 there were 28 deaths during the marathon race and up to 24 hours after finishing.

Lipinska [2006] obtained results (for every 5 km of a distance) of the best 50 men and women finishing marathon run in four top level competitions (Olympic Games, world championships, road/street running). In every run only the first few at the finish line had their distribution of velocity of the whole run positive, i.e. with increasing velocity comparing two halves of the run (Fig. 4A).

The best long distance runner in the world Haile Gebrselassie (ETH) when broke the world record time, he had positive distribution of velocity. This was twice in Berlin (2007 and 2008). When he went to Dubai he also wanted to break the world record since there was a quarter of million dollar prize for winning the run and additional 1 million dollar prize for breaking the record. Unfortunately, in Dubai Gebrselassie did not break the record (in three years). His distribution of velocity was negative (Fig. 4B). In addition his dispersion from the trend line (based on analysis of 1 km intervals) was not always correct. While the mean velocity for the whole marathon run was about 5.6-5.7 m/s he ran sometimes 6.0-6.1 m/s [Erdmann and Lipinska 2013].

According to Frederick [1983] the optimum ambient temperature range for marathon performance is about 10 – 15 °C. Buoncristiani and Martin [2012] even narrowed this range to 10-12°C. Taking into account long distance running during the hot weather (25 – 35 °C) competitors at 10 km and marathon begin their run with low velocity. After about three quarters of the distance it looks they feel not bad because they accelerate their run significantly. From the mechanical point of view it is not positive (Fig. 4C).

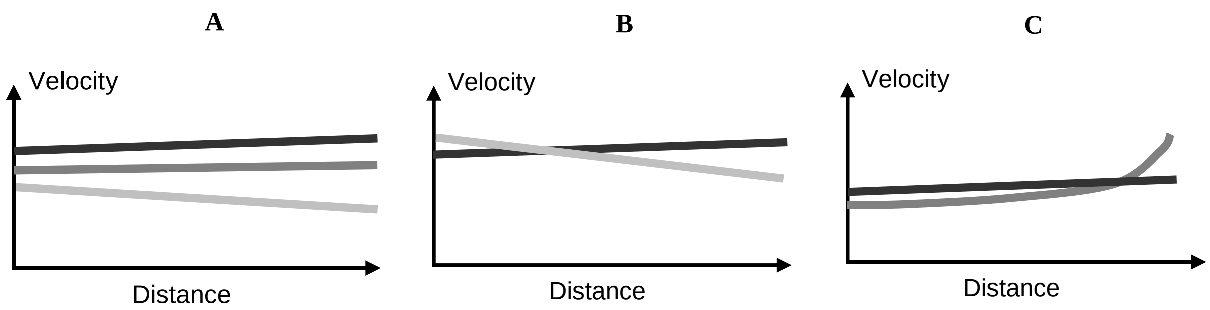


Figure 4. Distribution of velocity of long distance runners: A – the best few at the finish line had positive distribution (dark gray), runners from the second five of the first ten at the finish (medium gray) had more or less horizontal distribution, other runners of the first 50 at the finish line (light gray) had negative distribution; B – the best long distance runner Haile Gebrselassie when he broke world record had positive (dark gray) and when he failed in breaking a record he had negative (light gray) distribution; C – during hot weather runners begin their run too slowly and at the end they accelerate their run (medium gray); running with higher velocity generates higher air resistance, so the proper distribution would be consecutive small acceleration of the run (dark gray).

The author met Haile Gebrselassie (Fig 5A) and his manager and coach (Fig. 5B) and proposed a tactics for the record run. This proposition included (among other things) proper distribution of the velocity – slowly rising and with minimizing a dispersion from the trend line. In addition the author proposed running behind pace-makers in order to have smaller air resistance instead at the side of them (before, Haile ran in the middle and pace-makers ran at his sides). Next year in Berlin 2011 a new world record was obtained. But this record was not broken by Gebrselassie since he withdrew from the run at around 30 km because of his asthma problem, but by Patrick Makau (KEN) who ran all the time behind Gebrselassie. So, the tactics was set for Haile and Patrick benefited from it.

5. CONCLUSIONS. Professional sportspersons usually spend a lot of time to train for the highest possible level. The time is devoted for obtaining better fitness, for more excellence technique, for better mental preparation. The sportspersons usually do not train enough of time for the proper tactics of sport activity.

Since many sportspersons are very well prepared from the technical point of view they should spent more time on tactical approach to the sport activity. This can be transferred also on other than sport activities – in the professional work, in the army, during tourist and other activities.

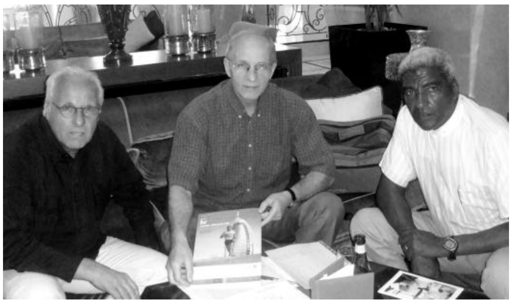
A  B 

Figure 5. Meeting of the author with: A – Haile Gebrselassie in Addis Ababa (ETH) in 2009, and B – with (from the left) manager Jos Hermens and coach Yilma Berta in Dubai (UAE) in 2010.

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Ердман В.

БІОМЕХАНІЧНІ ДОСЛІДЖЕННЯ ТАКТИКИ СПОРТИВНИХ ЛОКОМОЦІЙ У ГДАНСЬКУ

Гданські спортивні вчені беруть участь у кількох проектах з метою поліпшення виступу на спортивних змаганнях з позиції тактичної підготовки під час пересування в багатьох видах локомоторних рухів: спортивні ігри, гірські лижі, спортивний біг і ходьба та інших дисциплін. Отримані результати упроваджені в практичну діяльність тренерів і спортсменів.

Ключові слова: *біомеханічні дослідження, спортивні пересування, тактика, Гданськ.*

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