PUTTING BIOMECHANICAL INFORMATION INTO PRACTICAL USE

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In this keynote lecture, activities of the biomechanics research project of The Japan Association of Athletic Federations are first introduced with examples of speed and motion analyses of elite sprinters in world level competitions. The speaker explain various feedback processes of biomechanical information to athletes and coaches, and propose a procedure to bridge the gap between theory and practice. For effective use of biomechanical data in practice, we have to install two kinds of analysis abilities : a qualitative and quantitative analysis abilities. Without one of two abilities we will be unable to be a good sport biomechanist. A sensible quantitative analysis is derived from a sensitive qualitative analysis and the latter is improved by the former.

KEY WORDS: motion analysis, sport techniques, athletics, standard motion

INTRODUCTION

Sport biomechanics is an area of applied biomechanics in which we think about how we can improve sports performance and reduce the risk of injuries for sports-loving people and athletes by the use of effective sports techniques and training methods. Therefore, the primary aim of sport biomechanics is to contribute to improvement and optimization of sports techniques through investigation and analysis of skilled athletes' motions and to obtain insights into improvements in movement techniques, design of effective training methods, and prevention of injuries.

Reviewing the history of the development in various sports techniques and observing sport techniques that recent elite athletes demonstrate in highly-ranked competitions, we can categorize development types of sports techniques into three, i.e. empirical and creative type, improvement-based type, and theoretical type.

1) Empirical and creative type: Realization of creative ideas that athletes and coaches would incubate, without being shackled by stereotyped thinking and techniques
2) Improvement-based type: Realization of more effective techniques, based on studying, scientific understandings and improvement of the techniques of elite athletes
3) Theoretical type: Realization of more rational techniques that would be theoretically created from the body of knowledge relating to biomechanical characteristics of the human body

Although the empirical and creative type has been applied to most of cases in the modern high-level athletic sports, the improvement-based type is emerging with remarkable development in sport sciences and technology and is expected as a next driver of the improvement in sports techniques. The theoretical type has little contribution to recent sports techniques because of the lack of knowledge concerning sports techniques.

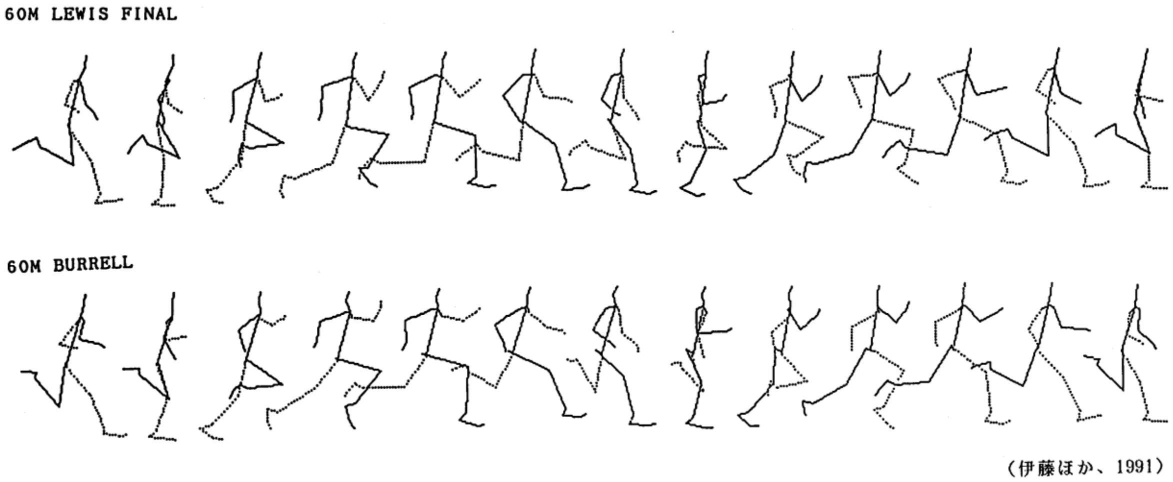
Not only in sport biomechanics but also in other areas of sport sciences, bridging the gap between theory and practice is one of important tasks. In general, theory or science aims to abstract some scientific principles from various phenomena, in our case sports movements, while practice or teaching/coaching aims to individualize and apply principles to solve problems of athletes. One possible way to bridge the gap between both would be to apply biomechanical information on excellent and skilled performers to practice, based on appropriate classification of athletes.

The scientific committee of The Japan Association of Athletic Federations, JAAF, has conducted well-organized biomechanics research projects to collect biomechanical data of elite athletes in official competitions and has attempted to put collected biomechanical information into practice for years, which can be a suitable case to gain insights into effective use of scientific data.

The purposes of this keynote lecture are to introduce the activities of biomechanics research projects of JAAF with demonstrating how we feedback sport biomechanics data to athletes and coaches, and to propose a procedure to bridge the gap between theory and practice.

ACTIVITIES OF THE SCIENTIFIC COMMITTEE OF JAAF

The systematic and organized activity of the biomechanics research project of JAAF started in 1991, taking the 3rd World Championships in Athletics, Tokyo as a good opportunity with a great help of JAAF, especially Professor Sasaki as a managing director of JAAF at that time. Figures 1 shows a tiny portion of the outcomes of the 1991 project, and the stick pictures of Lewis who finished the 100m sprint final at 9.86 s, world record, and Barrell running around the 60m mark which were reconstructed by three-dimensional DLT technique(Ito et al.,1994). The biomechanics research project has been carried out three to five projects in a year until now with landmark projects of The Asian Games in Hiroshima, 1994, The Universiade in



Fukuoka, 1995, the 11th IAAF World Championships in Athletics in Osaka, 2007 and so on.

Figure 1 Stick pictures of Lewis and Burrell at the men’s 100m final, 1991.

Figure 2 Changes in running speed(black line), stride length(blue) and stride frequency(green) of Gay in the 100m final, the 11th IAAF Championships, Osaka, 2007.

Figure 2 shows an example of 100m speed analysis, i.e. changes in sprint speed, step frequency and step length of Gay,9.85 s, in the final race of men’s 100m sprint.

We concentrated on collecting and accumulating scientific data of elite athletes from foreign countries in the first five years. However, the activity of the project has changed with the requests of athletes and coaches, continuing data collection of Japanese and foreign elite athletes actively. In 1992, members of the committee attempted to analyze the techniques of elite athletes from the biomechanical point of view in more detail, and started to give information obtained from analyses to athletes and coaches through conferences, coaching clinics, papers, magazines, books, VTR and so on. When we presented and explained the results of biomechanical analyses of the techniques of elite athletes, many coaches disagreed our interpretation and suggestions derived from analyses of the elite athletes.
Ito et al.(1994) revealed that the top male sprinters less extended their support knee and ankle joints at the instant of the toeoff, less raised their recovery thigh and so on, as shown in Figure 1. Most of coaches had believed that excellent sprinters should extend their support leg at the toeoff and raise the recovery thigh as high as possible and had coached their athletes, especially young athletes. The results presented by Ito et al. were very different from the existing theory of the sprint running techniques in Japan. After a lot of discussion and

argument, the biomechanical interpretation on the support leg revealed that the not-fully-extended support knee at the instant of the toeoff was more effective than full extension of the knee at the toeoff, by using relative movement analysis of the support leg. Many coaches began to change their theory and coaching methods after this.

These processes greatly helped us to build a close relationship between the scientific committee and athletes and coaches. Nowadays, members of the committee visit training camps of the Japanese elite athletes, consult their techniques and training methods with coaches in seminar rooms and stadiums. Therefore, in addition to collecting data and analyzing the techniques, the feedback of biomechanical information to athletes and coaches has become more important and significant activity than ever before.

FEEEDBACK OF BIOMECHANICAL INFORMATION TO ATHLETES AND COACHES

Our experience in the activities of JAAF indicates that there are four kinds of data feedback processes as follows.

1) Normal data feedback called Off-field feedback
   This feedback is called Off-field feedback because biomechanists collect data, leave from a stadium and analyze video images and it takes a long time, ex. a few months to present analyzed data to the athletes and coaches.
2) Semi-immediate feedback
   The data taken in training session or competitions are analyzed from a few hours to a few days, depending on the volume and quality required. This feedback is suitable to check faults which have been already recognized by athletes and coaches and monitor how the techniques are improved by practice and training.
3) Immediate feedback
   The data, i.e. video images and some force data collected with a force platform during training session are immediately presented to the athletes on the field in trial-by-trial manner. One of shortcomings of this feedback is in preparation of relatively expensive devices such as a force platform .
4) Suggestive or hypothetical feedback
   Based on the data collected for an athlete in a lot of training sessions and competitions throughout years, biomechanists will present some suggestion or hypothetical advices for the improvement in performance for elite athletes.

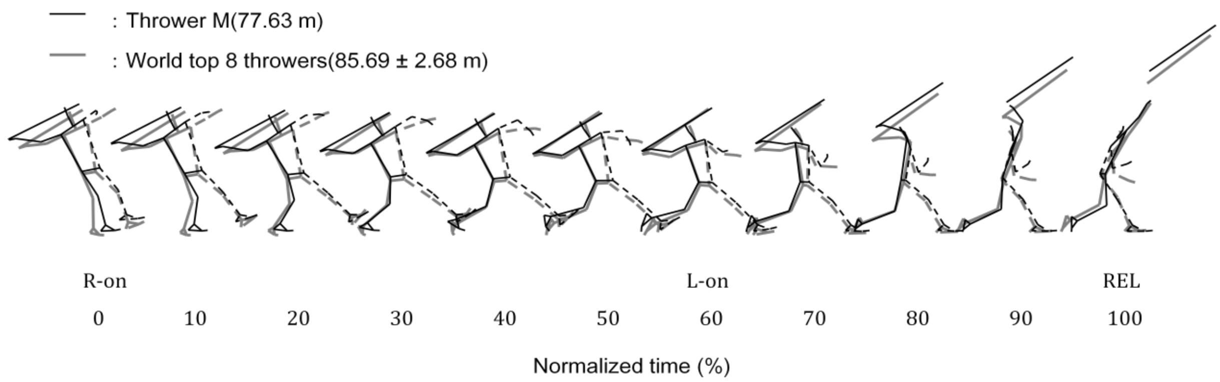


Figure 3 Stick pictures of the javelin throw for standard motion of the world top 8 throwers(grey line) and thrower M(black line), 2007.

Figure 3 shows a result of the suggestive feedback which Dr.Tauchi, a committee member, applied to the improvement in the technique of javelin thrower M. Tauchi et al. collected and analyzed world top javelin throwers in the 11th IAAF championships, Osaka 2007 with three-dimensional DLT technique. And they established the standard motion of elite male javelin throwers(85.69 ± 2.68 m) by using the method of Ae et al.(2007) and compared the standard motion with the techniques of thrower M(77.63 m). The comparison revealed that there was a serious difference in the movement of the throwing arm between the top 8 throwers and thrower M, that is the range of motion of the throwing arm for thrower M in the final phase was much smaller than that of the world top 8 throwers, as shown from the instant of the left foot-on, 60% in normalized time to 90%. Tauchi showed this result with numerical figures and animation of throwing motion to thrower M and his coach at the training camp, who subjectively recognized this difference but could not go ahead with change in techniques due to some reasons. However, presenting these pictures and serious discussion changed their mind to alter his techniques and training methods. After a year later, his motion of the throwing arm was changed so as to increase the range of motion, and he gained a bronze medal in IAAF Championships, Berlin 2009 with his personal best record of 83.10 m.

Through a lot of attempts to communicate with athletes and coaches, if we could establish a relationship of trust between researchers and athletes and coaches, the fourth feedback method would become a major way to put biomechanical information into practice.

IMPORTANCE OF CLASSIFYING ATHLETES' TECHNIQUES

It is well known in the teaching and coaching that the first step to learning and improving sports techniques is to imitate the motion of skilled performers as a template of model performance. This approach has some limitations; there may be motion variability even in a model technique that can be attributed to the characteristics of the model athlete, and there is no firm and valid base for determining model technique. However, we can overcome these limitations if we prepare some appropriate motion models for sports techniques(Ae et al., 2007). The average or standard motion pattern is sufficient for practical use. In addition to a beneficial point of the standard motion as a model techniques in technical training, the standard motion can be used as a reference to classify athletes' techniques.

Figure 4 shows three types of long jump techniques that collected in official competitions by using the DLT technique. The figures shown over the pictures are torso angle indicating a forward lean of the torso in negative. The stick pictures in the middle row is a standard motion. The top one is a typical example of the long jumper who maintained his trunk in relatively vertical position during the preparatory phase and at the instant of the takeoff foot touchdown. On the other hand, the long jumper in the lower row is characterized by earlier timing of the torso raise and larger backward lean of the torso at the takeoff foot touchdown. This implies that there are some types of sport techniques even in athletes of almost same performance.

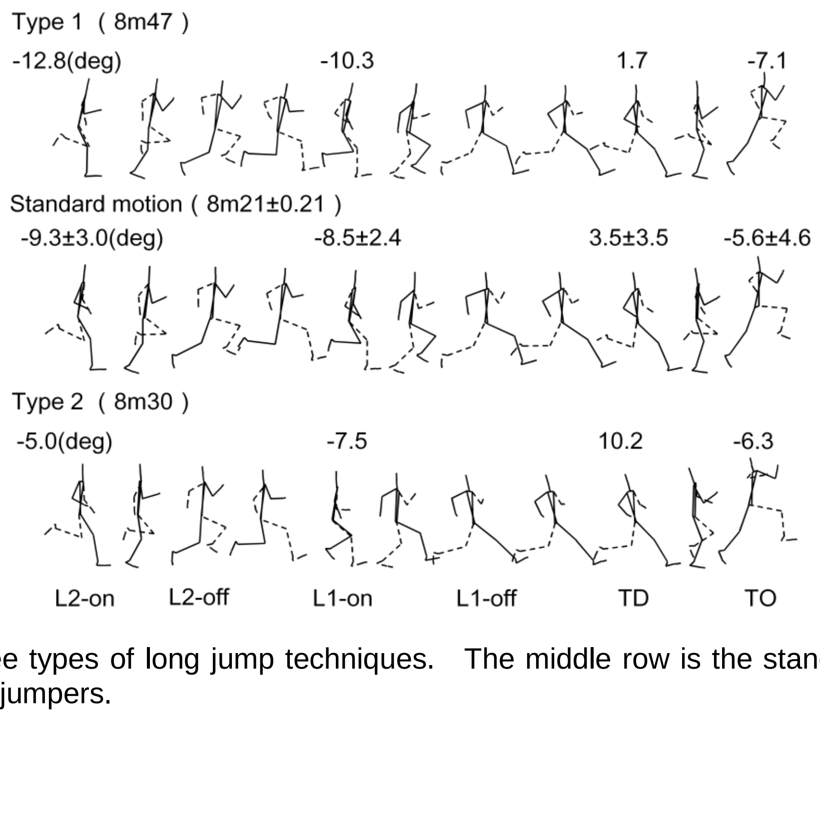


Figure 4 Three types of long jump techniques. The middle row is the standard motion of elite male long jumpers.

Fukashiro et al.(1994), a committee member of JAAF, analyzed two outstanding long jumpers, Powell, gold medalist, the world record holder of 8m95, and Lewis, silver medalist of 8m91, in the 3rd IAAF Championships, Tokyo,1991. They found that Powell jumped at the takeoff angle of 23.1 deg. and Lewis was 18.1 deg. and concluded that the world record of Powell was established by his large takeoff angle. However, our observation and data taken before and after 1991 indicated that Powell used to jump low as Lewis did, which was his own jumping style like type 1. His usual takeoff technique was very different from that of his world record jump which could be characterized by the large backward lean of the body and the raised torso and the swing thigh kept in back position. Referring to Figure 4 allows us to imagine that the technique of Powell in the world record can be categorized as the third type that is a desirable compromise of types 1 and 2.

As described in Introduction, since practice seeks for specialization and individualization of sports techniques for an athlete in question, classification of athletes is one of the key factors for effective application and feedback of biomechanical information.

CONCLUDING REMARKS

The recommended processes to effectively put biomechanical information into practical use are 1) collection and accumulation of biomechanical data from skilled athletes, 2) analysis and interpretation of the data, and the establishment of standard motion, if possible, 3) classification of athletes based on the standard motion and statistical analysis, and 4) feedback appropriate to athletes' individuality and specification derived from classification of athletes. These processes would be reinforced by the help of computer simulation, technology used for feedback as well as a relationship of trust, a scientific intuition and experience of researchers.

For effective use of biomechanical data in practice, we have to install two kinds of analysis abilities : qualitative and quantitative analysis abilities. Without one of two abilities we will be unable to be a good sport biomechanist. A sensible quantitative analysis is derived from a sensitive qualitative analysis and the latter is improved by the former.

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