THE NEXT STEPS FOR EXPANDING AND DEEPENING SPORT BIOMECHANICS

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Starting with introduction of the activities of biomechanics research projects of JAAF in which I was involved, how we conducted feedback of sport biomechanics data to athletes and coaches will be described. I will share ideas to find solutions to some long-standing questions in sport biomechanics and in the field, and to further expand and deepen sport biomechanics. Topics are learning from skilled athletes, exchanging basic and practical biomechanics, i.e. sport biomechanics, expanding sport biomechanics to practice in the field.

KEYWORDS : sport technique, skilled athlete, standard motion, optimization loop

INTRODUCTION

Sport biomechanics is an area of applied biomechanics, which aims to contribute to improvement and optimization of sports techniques through investigation and analysis of skilled athletes' motions, and to obtain insights into improvements in sport techniques, design of effective training methods and injury prevention. Out of tasks of sport biomechanics, studying and understanding human movement and sport techniques would be a core task of this area by learning from skilled athletes. For more than 20 years, I have served the scientific committee of The Japan Association of Athletic Federations, shortly JAAF, as well as studying skilled athletes in various sports such as Judo, speed skating, baseball, basketball, volleyball, and children's basic human movements. The committee 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 also help us gain insights into effective use of scientific data.

In the Goeffrey Dyson lecture, I will briefly introduce the activities of biomechanics research projects of JAAF in which I was involved, with demonstrating how we conducted feedback of sport biomechanics data to athletes and coaches, and to share ideas to find solutions to some long-standing questions in sport biomechanics and in the field, and to further expand and deepen sport biomechanics.

LEARNING FROM SKILLED ATHLETES

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. Although this approach seems to be simple and easy, it has some limitations; there may be motion variation and types 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 a model technique. However, we can overcome these limitations if we prepare some appropriate motion models for sports techniques. The average or standard motion pattern is one of tools that is sufficient for practical use. In addition to a beneficial point of the standard motion as a model technique in technical training, the standard motion can be used as a reference to classify athletes' techniques.

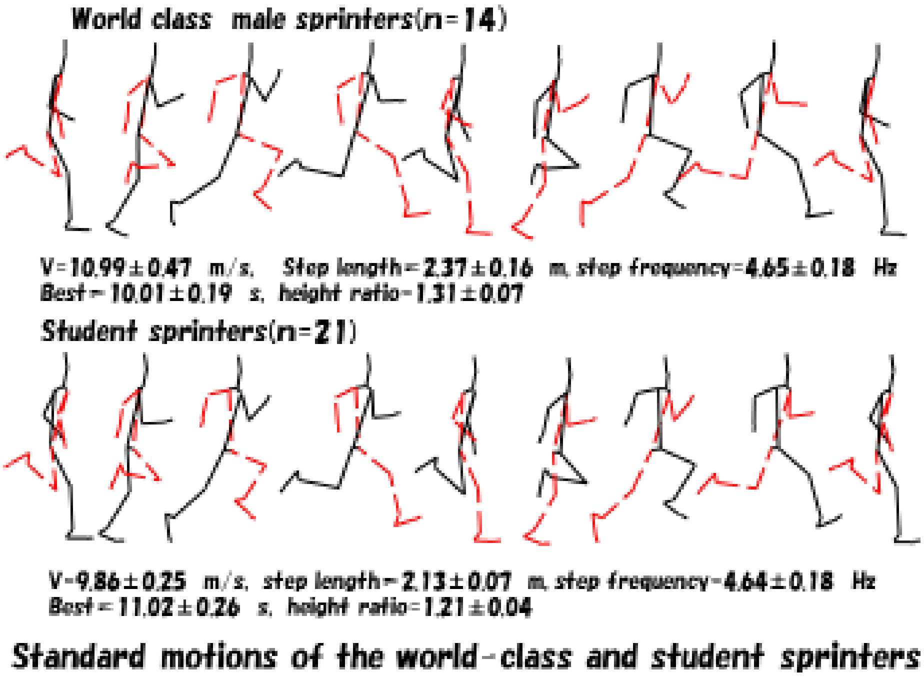

Figure 1: The averaged motions for the world class and student sprinters at 60m mark of 100m sprint.

Figure 1 shows the averaged motions for the world class sprinters and student sprinters at 60m mark of 100m sprint. At a glance, two motions seems very similar and there is no clear differences between them. However, if we closely look at their motions, for example, the shank of the support leg at the instant of toe-off, it is clear that the world class sprinters rotated the shank more forward, and would drive the center of gravity more forward at the toe-off than student sprinters. This finding would imply that forward rotation of the shank during the support phase is a key movement in sprint running and could be added to the knowledge for the optimization loop of sprint techniques.

EXCHANGING BETWEEN BASIC AND PRACTICAL BIOMECHANICS

There seems to be a lot of scientific problems which are derived from the area of sport biomechanics and in the field, and passed on basic biomechanics to be solved, as Figure 2 may exemplify a story.

Figure 2 shows the average absolute, positive, and negative works done by the joint torques in the lower limb joints during one cycle of running at different speeds for five skilled male sprinters (Ae et al., 1986). As the running speed increased, the positive work at the knee and ankle did not change remarkably, although that of the hip joint increased more at faster speeds than at medium-slow speeds. For the negative work, only work by the knee joint markedly increased with the running speed. Although the absolute work increased with speed, the largest increase was seen in the hip joint, followed by the knee and ankle joints.

The results raise a question why with the increase in the running speed, they recruited more proximal joints than the peripheral ones, implying that there may occur some switching in motion-decision criteria, i.e. objective functions to decide participation of the body segments, joints, muscles and nerves in our body. This is one of vital problems in biomechanics as well as in human movement sciences. If we found answers, we could predict a movement pattern or technique appropriate to accomplish tasks and solve problem going on before our eyes.

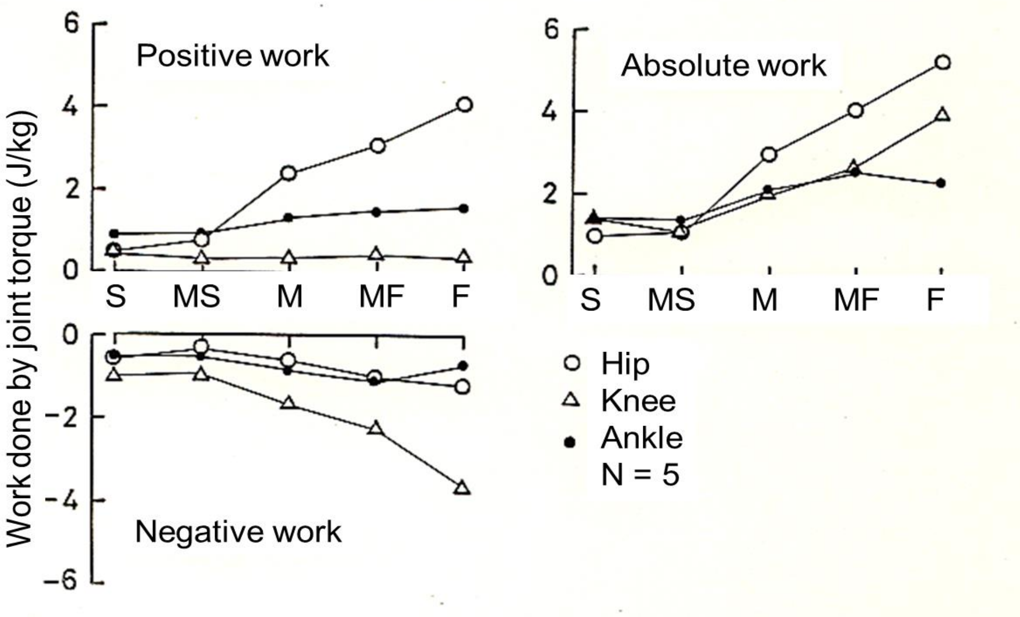

Figure 2: the average absolute, positive, and negative work done by the joint torques in the lower limb joints during one cycle of running at different speeds

EXPANDING SPORT BIOMECHANICS TO PRACTICE IN THE FIELD

Not only in sport biomechanics but also in other areas of sport science, bridging the gap between theory and practice is one of important issues. In general, theory considers human movement or sport performance as a physical fact, investigates it partially and analytically, and aims to normalize the results and finally abstract to some scientific principles from various phenomena.

On the other hand, practice or teaching/coaching considers human movement as a conscious and psychological fact, studies it in holistic and integrative view, and aims to individualize or apply principles to solve problems of athletes. In recent years, there are emerging areas which apply scientific findings and technology to practical area in teaching and coaching, which are becoming known as performance analysis, monitoring training and sport analytics. Knowing difference between theory and practice, and approaching each other, there are a lot of problems in teaching and coaching to which sport biomechanics properly contributes.

Figure 3 shows an example of the collaboration and creating something new together with theoretical and practical sides. We employ sport biomechanics in performance analysis and conducted data feedback collected and analysed to optimize sport techniques of athletes. From continuous exchanging activities, some research problems could be abstracted and proposed as basic research themes. These exchange and collaboration will expand and deepen our sport biomechanics in the end.

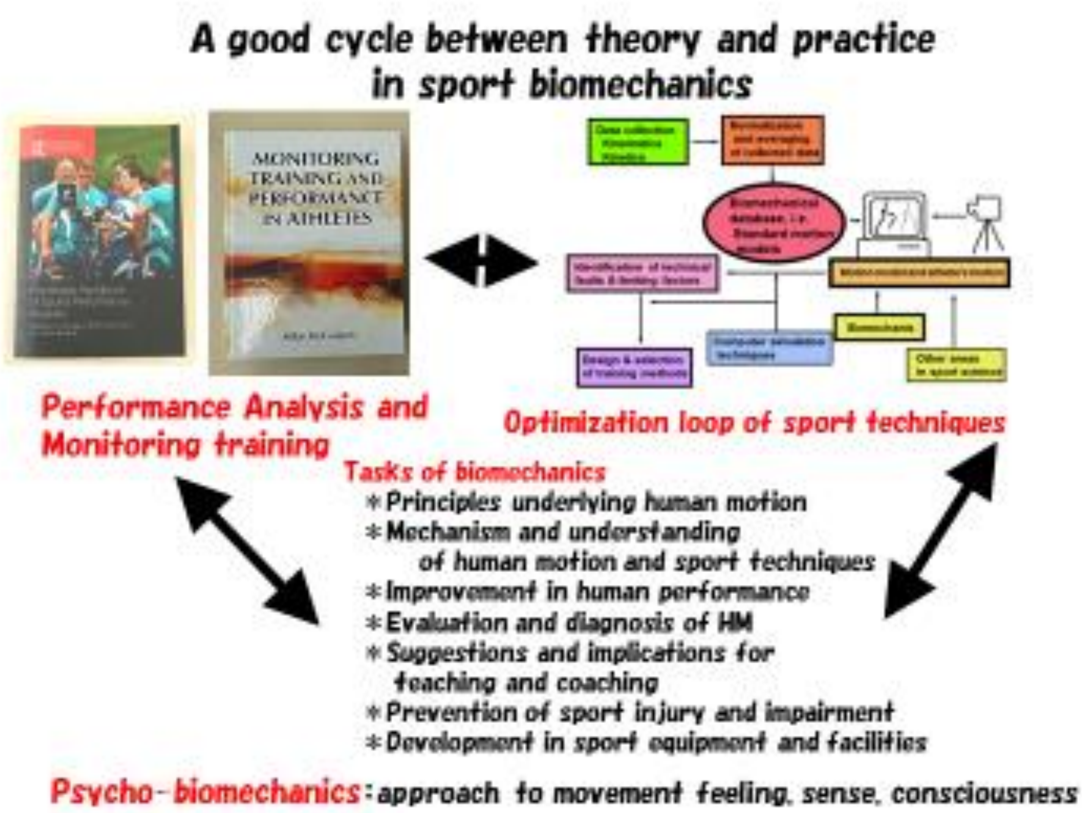

Figure 3: A good cycle between theory and practice

REFERENCES

Ae M, Muraki Y, Koyama H, Fujii N. (2007). A biomechanical method to establish a standard motion and identify critical motion by motion variability: With examples of high jump and sprint running. Bulletin of Institute of Health and Sport Sciences, University of Tsukuba, 30,5-12.

Murata K, Ae M, Uchiyama H and Fujii N. (2008). A biomechanical method to quantify motion deviation in the evaluation of sports techniques using the example of a basketball set shot. Bulltin of Institute of Health and Sport Sciences, University of Tsukuba, 31,91-99.

Ae, M. (2017). Sprint Running: Running at Maximum Speed, Handbook of Human Motion, Springer International Publishing AG, (eds.) Mueller, B. & Wolf, S. I. DOI 10.1007/978-3-319-30808-1_119-1

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