Biomechanical studies of athletes

During the Games of the XXVI Olympiad, the Centennial Games, in Atlanta in 1996, the most ambitious sport science research effort in the history of the Olympic Games was undertaken. The IOC Medical Commission’s Subcommission on Biomechanics and Physiology of Sport supervised the study of hundreds of Olympic athletes in seven different sports under competitive conditions to determine characteristics of their performance which dictate success and contribute to injury. The goal of these research projects was to document performances of Olympic athletes in competition and establish an archive for scientific and historical purposes. A further objective is to provide a scientific knowledge-base which coaches and athletes around the world can utilize to determine the optimum training programmes for athletes at all levels of performance in Olympic-related sports.

The biomechanical research projects in Atlanta furthered many of the historic scientific traditions established in past Olympic Games, beginning with the Games of the XXIII Olympiad in Los Angeles in 1984, but they also established several new and exciting traditions. The subcommission members felt it was important for the Atlanta projects to continue the research focus on sports which had been studied in past Games to determine the performance evolution which has occurred, while also targeting new sports and innovative research techniques which have not been studied or utilized during past Olympic competitions.

By virtue of the inclusion of several new sports under the auspices of the IOC Olympic Biomechanics Research Projects, the Atlanta research team will provide one of the broadest and, perhaps, the most comprehensive insights ever into the biomechanical aspects of Olympic sports competition. A total of fourteen investigations in eight sports were conducted by sport scientists from seven countries. The internationally recognized principal investigators for each study were supported by research assistants from their respective institutions, as well as sport science graduate students from two local universities; Georgia State University, the host laboratory to the IOC Subcommission on Biomechanics and Physiology of Sport during the Games, and the Georgia Institute of Technology. Each research team consisted of approximately seven members. In addition, members of the subcommission provided professional support and assisted in project coordination during the Games.

The traditionally studied Olympic sports which were included in the Atlanta projects, and their respective leaders, are as follows: javelin Professor Roger Bartlett (Great Britain); pole vault - Professor Peter McGinnis (USA), Dr. Josep Escoda (Spain) and Professor Yu Liu (Taiwan); equestrian cross country jumps, dressage and...
show jumps - Professor Nancy Deuel (USA); and swimming, temporal measures of all individual events - Professor David Smith (Canada). Professor Smith’s team of researchers used a very innovative and time-intensive technique to study the swimming competition. By videotaping each lane of each swimming race, the research team was able to measure numerous important biomechanical variables for each competitor. Upon completion of a race, each swimmer was provided a very detailed biomechanical analysis of his or her performance.

These printed results were widely distributed to coaches, athletes and other interested officials within a few hours of the competition. Before a swimmer competed in the next round, these results were available for consideration of competition strategies and performance adjustments. Professor Smith’s team analysed every swimming race over the course of the Games. When fully compiled, the biomechanical analysis of all competitors for all races nearly 1,000 pages of scientific information. The document was presented to the IOC the day following completion of the swimming competition.

The sports which were studied for the first time in Atlanta under Olympic competitive conditions were: triple jump - Professor James Hay (USA)/New Zealand); baseball aerodynamics of flight of a pitched ball - Professor Mont Hubbard (USA), baseball pitching mechanics - Dr. Glenn Fleisig (USA); diving, 10m platform and springboard - Professor Doris Miller (Canada); gymnastics, aerial mechanics of floor exercise - Professor Fred Yeadon (Great Britain), gymnastics, landing mechanics in apparatus dismounts - Professor Jill McNitt-Gray (USA); softball windmill pitching mechanics - Dr. Sherry Werner; and tennis serve stroke mechanics - Professor John Chow (Taiwan/USA), Dr. Glenn Fleisig (USA) and Professor Benjamin Johnson (USA).

Each of the research teams utilized specialized high-speed video recording instruments to capture the Olympic competitor’s performances on videotape for detailed study in laboratories around the world. These specialized video cameras record pictures onto videotape at the rate of up to 200 pictures per second. These video records are then analysed on a frame-by-frame basis by the sport scientists utilizing specialized computer software programmes which mathematically model the human body. The software then produces animations, graphs and tables of data which the scientist studies...
to determine the biomechanical techniques (motion, speed, and coordination) of the athletes and their success or failure at achieving their optimum performance. Additionally, computerized force measuring platforms were also employed in the data collection of Olympic 10m diving performances. The forces produced on the surface of the diving platform during the final push-off by all male and female 10m platform divers were measured to determine the amount and pattern of force production required for a successful diving performance. This force analysis will provide insights into the amount of muscle force required and, when combined with the video analysis, the complimentary movement techniques necessary to be an elite platform diver. Professor Miller is now preparing an educational CD-ROM on the findings of her Olympic diving research for distribution to interested divers and their coaches at all levels of competition.

Each of the projects will result in one or more detailed scientific papers to be published in the *Journal of Applied Biomechanics* or other respected, peer-reviewed professional sport science journals. In addition, documents directed to the coach and athlete will also be produced for each project. It is anticipated that the scientific information gathered from these projects will guide Olympic sports performance, training and competitions well into the future as numerous insights into the requirements for success at elite level are identified, and suggestions for the refinement of athletic and safety equipment incorporated into their respective sports. At present, data analysis has been completed on most of these projects and the majority are under review for publication within the year. To date, more than twenty presentations at professional scientific or sport-specific conferences have been made by the research team members.

Additionally, videos will be produced which provide detailed audio-visual information regarding the significant findings of the respective sports. It is anticipated that these videos will provide both practical and scientific information on the biomechanics of Olympic athlete performance as well as the science behind developing healthy lifestyles among the general public. These videos will be produced and distributed through the IOC Subcommission on Biomechanics and Physiology of Sport to interested coaches, athletes, officials, sport scientists and educators around the world.

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