PROVIDING A SERVICE TO AN ELITE NATIONAL SPORTS PROGRAMME

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How well is Sports Biomechanics able to advance elite athletic performance at the national sporting level? Individual sports that involve a high technical skill level and that are repetitive are most suited to biomechanical support. An emphasis on servicing as opposed to research in the biomechanical support of a national sporting body tends to provide the better results in elevating elite performance. Biomechanics brings to the coach of elite athletes objectivity and quantification with advice from a biomechanical and technical perspective. One important aspect of servicing an elite national sporting body is the development of biomechanical testing systems in which the timeliness of feedback is of paramount importance. To be most effective there are certain ingredients that make for the ideal biomechanical testing system for servicing the elite arm of a sport. An example of such a system developed for elite swimming performance is provided. To be an effective sport biomechanist there is a need for specialisation in sport. Many other factors affect the success of a biomechanics programme apart from the science involved. Competition analysis provides much relevant information to elite sport and it also affects a large number of athletes. Once problems are disclosed through competition analysis they need to be addressed in a training environment using biomechanical systems to assist the coach.

KEY WORDS: biomechanics, elite sport, swimming, competition analysis, biomechanical servicing

INTRODUCTION: Science for science sake serves little purpose in advancing the cause of humanity. The benefit of a scientific discipline may be judged by how much it provides to the community in general, or how it contributes to another scientific discipline that in turn serves mankind. If the science discipline does nothing but provide purely a better understanding of the scientific processes involved for the betterment of the science discipline itself, is it of any real worth to mankind? Biomechanics is regarded by many people involved in sport as a sport science discipline that is a vital component in the development of modern day elite international performance. Others believe that sports biomechanics does little for performance apart from explain in scientific terminology, what the coaches of elite performers have already discovered. How well does our discipline of sports biomechanics measure up given this as the criterion for judging its worth in the area of improving elite sports performance? In what ways can the discipline of sports biomechanics make a significant contribution to the elevation of elite athletic performance? What is the best approach for sports biomechanists to make a significant contribution to elite performance at the national level? Who is best situated to make a judgement call as to how well sports biomechanics provides real value to sport?

I have been employed at the Australian Institute of Sport for eighteen years as head of the Biomechanics Department. I would like to relate my experience in this role with a view to addressing the above listed questions. My primary function at the A.I.S. was firstly to ensure that the resident sports at the Institute were provided with high quality biomechanics support designed to improve their level of elite performance. This was later extended, as a secondary function, to providing support to the national sporting bodies. Initially my work involved supporting a large number of sports. Naturally enough, the sports that could gain most from biomechanical support received more attention than those that I believed could not significantly gain from the biomechanical interaction. The general criteria used here was: individual, as opposed to team sports, could gain more; technique intensive sports, as opposed to more endurance type sports, could gain most; and sports that involved more repetitive type of activities could gain more than those that involved one off activities. For example, an individual sport such as Track and Field Athletics could gain more than a team sport such as Football where tactics played a more dominant role. A sport such as Cycling that is very technique oriented could gain more than a sport such as Orienteering that is more endurance and tactics based. An activity such as rowing, where a particular activity is repeated a large number of times, could gain more than an activity such as the jump events in Track and Field Athletics that is performed only a few times in each competition. The last example is based upon the theory that a small improvement made to a single stroke, which when multiplied by the large number of strokes made in the competition, would then result in a significant difference overall in competition. Initially, at the Australian Institute of Sport, the type of biomechanical support provided to the sports was developed as a consequence of the coach wanting to have more detail about a particular feature of his or her sport in a training environment. Simple apparatus was set up to objectively monitor the performance of athletes and provide an objective and quantifiable measure of what was happening. As an example of such biomechanical interaction, a force transducer interfaced to a computer may have been incorporated into a rowing ergometer to measure and display the force versus time history of each stroke.

When I first commenced at the AIS, sports biomechanics was purely of academic interest to elite sport. Although some biomechanical studies were involved with elite sport, these studies were spasmodic in nature and only provided limited assistance to a few elite athletes. No national sporting bodies utilised the sports biomechanics discipline extensively in the development and refinement of talent in their sport. The success of years of developing, refining and providing extensive biomechanical support to Australia's elite swimmers resulted in Australian Swimming recognising the contribution that biomechanics made to performance in its sport. In the last two years, AIS Biomechanics received the award of outstanding contribution to performance in Australian swimming by the Australian Swim Coaches and Teachers Association. As well as provide a continual contribution to many of Australian Swimming National event camps, AIS Biomechanics has been included as part of our national swimming teams over the last six years in the preparation for and during international competition. The other AIS biomechanists applied a similar approach in supporting their sports, as was the case in swimming. This resulted in their inclusion as part of Australian National teams in Cycling, Track and Field Athletics, Rowing and Canoe/Kayaking. This is in a climate where it is still very unusual to find sports biomechanists as part of national sporting teams at major international competitions.

A very important question needs to be asked of any national sports biomechanics programme at an early point in time. What is needed to elevate the level of elite performance of a national sporting body – Servicing or Research? Before attempting to answer this question I would like to define want I believe to be the meaning of each. Servicing is testing of an athlete or group of athletes designed primarily to improve the performance of the athlete or group of athletes being tested. Research on the other hand is athlete testing which is designed to come up with the answer to a question that has applicability to the performance of the group of athletes that the subjects of the research represent. Servicing aims at directly improving the performance of the athletes being tested while research is designed to develop principles upon which improved performance is based. My experience with both research and servicing suggests that good servicing provides an immediate infusion of ideas upon which to improve performance for the athletes concerned. Good research, on the other hand, provides answers to important questions. Research findings take some time to be taken up and applied by the coaching fraternity. Such research findings have a slower application but have the ability to affect a larger group of athletes. The writing up and education process associated with the research findings plays an important role on whether and how quickly research findings are utilised by elite sport. Pure research and pure servicing also lie on a continuum and are opposite extremes on that continuum. In reality, the distinction between research and servicing is not easily defined when the two are closer together on that continuum. I will now provide my answer to the question that I raised earlier in this paragraph. I believe and found that servicing of a large number of elite athletes has the capacity to most influence performance for a national sporting body. For a servicing programme to be effective, the programme must fulfil a number of prerequisites. These prerequisites include: the testing results in information which can improve performance; an extensive education programme associated with the testing must provide the coach with an understanding of the purpose, the results and how the information is able to be used to improve performance; the testing is carried out quickly and the results are provided in a timely fashion; and that information from the testing is provided in an easily understood format. Organised servicing will eventually lead to important questions that are raised by coaches and that need to be answered if the servicing programme is to remain effective. Research projects arise as a consequence of the sports biomechanist attempting to answer such questions.

It is my belief that the benefit that biomechanics brings to elite sport is its ability of providing objectivity and quantification in the measurement of technique performance in a sporting activity. Biomechanics is then able to apply this information, incorporating knowledge from both biomechanical principles and experience in the sport, to isolate inefficiencies of a technique nature and to develop and propose possible strategies for eradicating such inefficiencies. A sport's biomechanist is not a technique coach. The sports biomechanist is there to provide biomechanical advice together with information from biomechanical testing to the coach. The biomechanist should not be responsible to guide the athlete with changes to the athlete's technique. This is the function of the technique coach or the general coach of the athlete. The art of technique coaching is very specialised and is not necessarily something that a good sport biomechanist will be skilled in performing. The biomechanist must provide the technique coach with advice on changes that needs to be made to the athlete's technique based upon the results identified from biomechanical testing. While some biomechanists have coaching experience in the sport and may be willing to assist the athlete in changing the technique employed, this is rather the exception than the rule. Biomechanists should only operate in this way if they feel comfortable in the role of being a technique coach and only if they are asked to do so by the athlete's coach. A biomechanist does not need to be a technique coach to fulfil the role of a good sport biomechanist.

The biomechanical testing equipment for a particular sport is not something that can be purchased over the counter or ordered through a catalogue. A major aspect of the biomechanist's work is the development of biomechanical systems that can measure those parameters that best enable an evaluation of the activity under question. For such development to occur the biomechanist must, in conjunction with the coach, decide what aspects of the sport needs to be biomechanically evaluated and what parameters need to be measured to best enable this evaluation. The biomechanist then needs to identify the transducers that will most effectively monitor these parameters and decide upon how best to utilise the transducers in the testing system. If possible, computers with analogue to digital cards, or frame grabber cards if the transducer is a video camera, can be used to collect the signal from the transducers and this will enable a quick capture, processing and display of the parameters being monitored. Effort must also be expended in providing a concise and easily understood format for the interpretation of the results. This will readily aid in explaining the results of the Biomechanics testing to the coach.

Certain features of a biomechanical testing system improve its capability as a servicing tool. In a service environment, probably the most important feature of a system is the turn around time taken to provide information from the testing back to the coach. Naturally, there is a trade off between accuracy and turn around time. In general, the turn around time for information from kinematic sources is much greater than from kinetic sources. The biomechanist needs to establish the accuracy level required in the servicing environment. In most cases the accuracy level required in servicing is not as great as that required in research. Once the required accuracy is reached by the testing system, the emphasis should be on decreasing the time required to get the information from the system to the coach. Immediate feedback provides the opportunity for a test, retest situation with the coach providing input to the athlete's performance prior to the retest. If the athlete is also able to practise the skill before the retest, this repetitive process provides probably the most ideal approach to skill development. Other beneficial features of a biomechanical testing system are a quick set up and pull down time, the fact that few operators are required for testing and processing of data, automatic rather than operator input into the measurement aspects of the system, and that little interference is caused by the testing environment to the athlete's normal performance. If the output biomechanical parameters from the testing system are superimposed over a video picture of the performance, this provides the measured biomechanical parameters in conjunction with a recorded image of the performance. The coach is readily able to identify with an image of the performance, making the biomechanical feedback from the system almost self-explanatory for the coach.

At the AIS, the biomechanics department developed an instrumented starting block to examine swim start technique. As a force platform was incorporated into the block, the system was able to monitor the force pattern exerted by the swimmer on the block in relation to the start signal. The reaction time, the force pattern developed by the athlete, the time taken to leave the block, the angle of takeoff (movement direction of the swimmer's C of G at the moment of leaving the block), the horizontal velocity off the block and the average acceleration from the starting signal until the athlete left the block were all monitored. The output of this part of the biomechanical testing system was produced in the form of a graph and was available within a minute of the start. The equipment was based around a kinetic transducer system, linked to an analogue to digital card in a computer. In order to monitor the swimmer through the air, a video based system was utilised in which the video signal was captured by a frame grabber card into the computer. This enabled the operator to obtain the Cartesian coordinates of the swimmer's body at various aspects throughout the air borne phase of the start. Stick figure diagrams of the swimmer's body at these distinct aspects of the airborne phase of the dive were plotted out to indicate starting form for the coach. The angle of the trunk at the various aspects and the distance and time of entry into the water from the block was indicated on the diagram. A similar system using an underwater tracking camera monitored the underwater phase of the swim start. This part of the testing system was kinematic based and took up to five minutes to produce the stick figure diagrammatic output for a single start. This delay was associated with digitising the location of the swimmer's landmarks from the video image. Although the output from this entire system was comprehensive, the main disadvantages of the system were associated with the time lag between testing and the output being available, the number of testers required to operate the system, as well as the time for set up and pull down of the system. This system had the added disadvantage that it could only be utilised in the AIS pool in Canberra. This is an example of a biomechanical servicing system. As an example of the information that is produced from the kinetic system I will provide average data for Australian Male Butterfly swimmers. Start Time (head to 15m) = 6.51 sec, Movement time (after start signal) = 0.14 sec, Time to leave Block = 0.82 sec, Horizontal velocity at leaving the block = 4.39 m/s, Angle of C of G to leave block = 1.23 deg downward, Average acceleration off the block = 5.34 m/s/s.

To make a significant difference to performance at the elite national level of a sport, there was a real need for specialisation in sports biomechanics. Over the last ten years it became obvious that it was necessary for each of the five biomechanists at the Institute to concentrate their effort on one major sport. However, as well as service the major sport, other minor sports also needed to be covered by each biomechanist. The major sports in the AIS Biomechanics Department are: Swimming, Track and Field Athletics, Rowing, Cycling and Canoe/Kayaking. There were a number of factors that made the specialisation vital for the AIS Biomechanics Department to positively influence elite performance nation wide through the national sporting bodies. The biomechanists needed to thoroughly understand technique in the sport in which they worked to effectively service that sport. This could not be achieved if the biomechanist was working in a range of different sports. The development of biomechanical testing systems for the sport was a major component of the biomechanists job and the biomechanist needed to concentrate on only one sport to develop effective biomechanical testing systems for that sport. A national education programme for coaches needed to be effectively implemented to complement the testing servicing programme. Prominent coaches needed to know and gain confidence in the biomechanist with whom they worked and this would only be possible if the biomechanist spent sufficient time working with them. To work effectively at the national level the biomechanist needed to know and work with the power brokers in each sport. To develop continuity in the national biomechanics support programme for a particular sport, one biomechanist needed to drive that program over an extended period and be recognised by coaches and administrators in the sport as the individual responsible for the programme. Another aspect that made AIS biomechanics an effective programme in enhancing elite national athletic performance was the development of permanent teams within the department. The team involved with the biomechanist in a particular sport consisted of the professional support officer, technical officer and biomechanics scholarship holder. There appeared to be a need for the critical mass of the entire team with individual responsibilities to drive each programme forward. Associated with each team there was specific biomechanical equipment that belonged predominantly to that team.

Probably the major aspect that influenced the effectiveness of the AIS Biomechanics support programme in swimming was the introduction of Competition Analysis. While such analysis was reasonably basic it provided information to many elite swimmers and for this reason influenced the sport to a large degree. It is only in major competitions that swimmers will produce a maximum effort and this is where an assessment of the swimmer's performance should occur. An analysis of individual swimmer's races at major competitions will provide information concerning each swimmer's weaknesses and their ability to follow the race model in competition. The race analysis information may also lead to a refinement in the swimmer's competition or race model. When the information from the competition analysis is spread sheeted along with that from other competitors it is easy for the coach to identify why each race was won and lost. The competition model for a swimmer is the intricate race plan for the swimmer and in this age of high tech international competition it is paramount importance to performance. It determines not only the split times for the various laps but it also defines how each lap is to be completed. It includes start and turn times as well as the stroke frequencies and stroke lengths that swimmers must maintain throughout the various laps of the race. Everything in the training programme of the swimmer is geared toward refining and practising the race plan. Competition analysis also reveals a swimmer's weaknesses that then can receive special treatment in the training programme. Competition analysis also enables statistical analysis on the data to identify new trends in competition swimming, as well as the affect of rule change on performance. When we perform competition analysis at major swimming meets in Australia we utilise many analysers in the project. This has the effect of bringing university students of human movement into an environment where they are working with elite sport. This exposes a large number of potential sport scientists to an experience in sports biomechanics. Some of the information obtained through race analysis includes data concerning: start, turn and finish times, split 25m times, and stroke lengths, stroke frequencies, velocities and efficiency indices for the free swimming phases in each event. The information from the competition analysis is distributed around Australia. This has the effect of providing performance information about Australia's top athletes to elite swimming centres around the nation. This in turn provides performance based information to the pool of emerging talent that is able to be used as a base in constructing a competition model for these developing swimmers. The competition analysis system that AIS Biomechanics uses for major swimming competitions on home soil involves much equipment and a large number of individuals in teams to process the information. For smaller meets in Australia and when travelling with the Australian team at overseas meets a single operator analysis system called SWAN is used. The limitation of SWAN is that for each SWAN system only a single swimmer can be analysed in a race. The operator needs to be skilled at the SWAN system to obtain reliable results. The advantage of the SWAN system is that the results are available immediately following the race together with footage of the swimmer's performance. The analysis of the swimmer's performance is processed as the race progresses. As well as provide the competition analysis information on a printed sheet it is also overlayed on the video image of the swimmers performance.

When weaknesses are identified by competition analysis in the performance of a swimmer these weaknesses need to be addressed by the swimmer's coach if the swimmer is to remain competitive in international competition. To assist in this process the SWAN system is capable of analysing, starts, turns, relay changeovers and free swimming technique in a training environment. As well as break down each of these skills into phases, an underwater video in which the camera moves along with the swimmer is provided to assist the coach. Timing information about the breakdown of the swimming skills of the swimmer is provided to the coach with comparative data derived from Australia's elite swimmers so that the coach is able to easily identify problem areas. Such analysis is frequently required by the AIS coaches in Canberra, by national team coaches in national orientation camps and by national event coaches at national event camps. As an example I provide comparative data used in turns for Australian male 1500 metre swimmers. The criterion measure for turn performance, which is the average time for the head to travel from 7.5m on way in to 7.5m on way out, is 8.49sec (1.77m/s). This is comprised of a pre-rotation phase (1.52m/s); a rotation period of 0.73 sec; a push off period of 0.4sec; and an underwater phase of 1.84 sec (1.87m/s) with breakout of 5.29m from wall.

Two other major areas in which AIS Biomechanics is working to enhance national swim performance are comparative three dimension modelling and the measurement of active drag of swimmers. The three dimensional modelling of swimmers can be used in two major areas. When the swimmer's performance goes through a slump, the modelling may be used to identify changes that have occurred in the swimmers technique. Modelling may also be used to compare the technique of two swimmers who have never actually swum together. Active drag analysis when measured accurately may be used as a means to objectively assess free swimming efficiency. This is on the basis that one of the two major aspects that affect free swimming velocity is the ability to streamline and to reduce drag.

To now answer the questions that I raised in the first paragraph of this paper. As can be shown, sports biomechanics can measure up well in the area of improving elite sports performance and making a significant contribution to the elevation of elite athletic performance. It has likewise been shown that a service provider to the national body of the sport can positively affect elite performance at the national level. Research is best derived as a consequence of questions that arise out of the servicing programme. The coach is probably best situated as the client, to make a judgement call as to how well sports biomechanics provides real value to sport.