Sport studies: from biomechanics to neurophysiology

sport performance studies in the new century will be focusing on brain

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***Abstract*—While research in the field of biomechanics applied to sport in the never ending effort of boosting sport perfomances is reaching the limit, neurophysiology disciplines, besides sport psychology, is gaining a lot of attention. As a matter of fact the ability in controlling the body and in understanding the situation from a cognitive point of view opens a new scenario in sport medicine and research. In the keynote the state of the art will be discussed with the last application of brain research to sport.**

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I. INTRODUCTION

Sport performance evaluation has been a must for decades in the never-ending effort to ameliorate results. As a matter of fact evaluation, or measure of the sport activity or sport gesture, is intrinsic in competition because the winner is often declared on the basis of some "measure" of his performance (time to reach the arrival or a given target, length or height jumped, etc.). When a precise or objective measure is not available (or when it was not available) competition uses the ranking of the competitors themselves as a measure: the first wins!

By the way let me express my personal and extremely negative view against the sport of boxing. Indeed while a concussion or cerebral trauma may be an unwanted, although possible, accident in any sport practice, this is the scope of the game in boxing (knock-out). So the "measure" of the performance in this kind of sport is a brain damage provoked in the antagonist. That's why I personally consider this kind of sport as intrinsically unethical. But this is my personal opinion.

With time the athletes and their coaches were more and more interested in measuring not only the results of a given sport gesture or activity (length where the javelin was thrown, time to run 100 meters), but also to measure the movements of the athlete in doing the performance. The scope of it was to ameliorate the performance, to optimize and adapt the training, so to indirectly boost sport results in the real competition.

As soon as microcomputers, electronics, miniaturized sensors were available, the athletes and their coaches started measuring anything which was possible to measure. Initially they started on step stride, elongation of legs, speed, acceleration, etc. Then more technical measures let it possible to measure the biomechanical variables in the movement and eventually these measures were coupled with a biomechanical model of the athlete. The results were astonishing. Coaching and training of the athletes were optimized to the least detail and sport results were boosting. The interest to the biomechanical details is also testified by the "biomechanical knowledge" many coaches have. They can very precisely discuss about the position or posture of the body in many sport disciplines, the application of forces or couples at the right times in the right places. This knowledge also improved the development of sports goods, from special shoes to any sport wearable, and also the sports devices from a racket to a row. Anything was created with usability and biomechanical friendliness in mind.

We may say that we reached, or we are approaching very near, the top of the art in this field.

By the way since the 60s, or maybe just starting soon after the WWII, a few researchers started working on the problem of understanding not just how the human body is moving, but how the brain and the nervous system more in general is able to control the movement of the human body. The paradigm was in such a way modified because it was clear that even the best trained body (from a biomechanical point of view) is useless if the nervous system is not trained at the same time to exploit it at the best.

To do this, new sensors and new measures were needed along with new methodological tools.

Initially the performance of the human body was not only studied in terms of the "body machine", instead the capabilities to understand a given situation, and reply to it accordingly and efficiently, were investigated. This implies the use of powerful cognition capabilities of the human brain, so the performances were considered in terms of signal processing by the human brain. The first studies were conducted by researchers involved in the assessment of human brain capabilities to control an external machine.

With the formalization of control theory in the 40s many technical problems received substantial and robust solutions like controlling the flight of a missile or an aeroplane. But when the controlled of this kind of machines is a human,

problems arise as to the needed cognitive, not only mechanical, performances of the human being as a pilot. Military pilots and astronauts received attention first. Top gun pilots must not only be trained from the physical point of view but also from the psychological point of view, besides being selected from the neurological point of view. The same was true for early astronauts, before the technology improved at the point the space navigation is possible almost for anybody.

The use of control theory tools for modelling the human being implies, as the word says, the creation of a mathematic model of the human being in controlling himself besides the machine he is at the control of.

Unfortunately enough control theory is not something which is very palatable to athletes or coaches, so most of these studies remained into the military or astronautics research centres. Furthermore, when sensors and measures are required, it happens that electroencephalography EEG recordings are needed and these facilities are not in the range of standard athletes and coaches. EEG systems were cumbersome, difficult to use, sensible to movement and interferences, so they were impossible to be operated outside super-equipped laboratories. Modelling of EEG signal able to be exploited for improving athletes' performance or training is also limited and a problem of communication is present to let the trainer understand this new kind of measure.

II. THE FUTURE SCENARIO

Nevertheless EEG systems and other neurophysiology systems along with vital signs monitoring are going wearable and many of the limitations which impeded current application of neurophysiology methodologies in sport are now evanishing. Wearable radio-connected EEG systems can now be used even in very active sports and EEG analysis can now be performed in real time with powerful digital signal processors.

What remain uncertain for the development of these techniques and their final use in sport coaching and training is the cultural preparation of the athletes and coaches themselves.

As we said before, coaches and athletes are very keen with biomechanics and other physical measures and models, but they are less adequate in brain research. They don't have even the words to use for understanding these phenomena.

We made a series of experiences for detecting brain cognitive evoked potentials in the sport of archery. We were able to detect evoked potentials at the moment of aiming and throw and this was possible to relate to the level of performances of the athlete (novice or experienced). These findings might well be used for optimizing or evaluating coaching and training activities. Many more sport activities can be affected by brain studies and the application of those.

No surprise, in the future the brain research will be done on the sport field and preliminary results are very interesting.

In conclusion we should stress a series of recommendations:

a) educate coaches and athletes in the neurophysiology field

b) develop even more advanced, easy to use, unobtrusive, sport acceptable devices for monitoring

c) develop fast and reliable acquisition systems with telemonitoring of data

d) select robust data and useful information able to impact athlete training and coaching

e) create understandable interfaces in providing data to the users

This century will be strongly marked by brain research and the sport domain will exploit it very much. Just be there.