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# Climatological Analysis, Weather Forecast and Sport Performance: Which are the Connections?

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The effect of weather and environmental conditions on sports has been extensively studied over the last few years [1-4]. Based upon the studies of Lobozewicz [5] and of Kay and Vamplew [6], Pezzoli and Cristofori [7] have studied the impact of some specific environmental parameters over different sports using a particular impact index divided into five classes.

This analysis clearly shows that most of the outdoor sport activities, and in particular endurance sports, are strongly influenced by the variation of meteorological parameters. In effect the evaluation of bio-climatological conditions and of thermal comfort in endurance sports, particularly in road cycling, has a fundamental importance not only for a proper planning of the training program and the nutritional plan, but also for a better evaluation of the race strategy [8]. Despite these observations, the influence of meteorological and environmental conditions is often disregarded in the outdoor sport performance assessment.

Among the meteorological variables that strongly influence the sporting activity the most important are temperature, wind, precipitation, fog, atmospheric pressure and relative humidity. The usefulness of weather forecasts in performance sports management has been demonstrated by Pezzoli and Cristofori [7] and Pezzoli et al. [9]. The results obtained by the Authors show us how the role of the meteorological parameters becomes crucial for sporting activities carried out in an outdoor environment.

The aim of this Editorial is to assess how many atmospheric variables may influence both the athletic performance and the comfort level for different sport disciplines. The availability of these specific information leads to have a more detailed knowledge of the area of interest and opens up the possibility of making considerations on past trends, as well as on the predictability of future situations and phenomena.

Based on Lobozewicz [5], Kay and Vamplew [6] and Pezzoli and Cristofori [7] studies, we conducted a qualitative-quantitative assessment of the influence of environmental variables on sport performance using the Haddon matrix [10].

William Haddon Jr developed his conceptual model, the Haddon matrix, in 1980. Since that time, the matrix has been used as a tool to assist in developing ideas for preventing injuries of many types.

The application of the Haddon matrix in the field of the sports activities allows determining the factors that mostly affect the performance, such as:

- Personal factors (psychophysical preparation)
- Vector or Agent Factors (materials and opponent)
- Physical environmental factors (meteorological and environmental analysis). Hereafter the "Physical Environmental factors" will be called "environmental parameters" and they will be referred to meteorological parameters (i.e.: air temperature, air humidity, wind, rain, etc…) that affect the sport performance
- Socio-environmental factors (of internal and external social environment).

This study illustrated the different methodologies used for the analysis of the environmental parameters during the different temporal phases of a specific sport event. During the pre-event phase a climatological and statistical analysis proves to be the most suitable. On the other hand, during the event a deterministic forecast methodology, associated with very short-term numerical weather prediction models, is suggested. Finally in the post-event phase meteorological measurements can be used, if available, for refining the performance analysis.

If the environmental parameters are not taken into account, one column would be missing within the Haddon matrix and hence an error would be produced using the performance assessment model.

The importance of Environmental Analysis for sport performance is often underestimated by coaches and managers. This is mostly due to the lack of knowledge about the added value brought by innovative techniques for measuring environmental variables and for predicting meteorological parameters.

The different time-scales for a proper environmental analysis and the weather forecasting during a general sport event can be divided as follows:

- Long term (up to 30 days before the event)
- Medium term (from 30 days before the event to 8 days before the event)
- Short term (from 8 days to 6 hours before the event)
- Very short term (from 6 hours before the event until the 'action').

This subdivision and the related weather forecast have to be used with regard to the possibilities offered by each Sports' Rule for what concerns the use of meteorological information.

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With this kind of meteorological analysis, and according to the Haddon matrix, a proper assessment of the environmental parameter is assured.

A series of in-depth focus groups conducted with different stakeholders (athletes, coaches, managers, performance analysts) coming from the main National Sports Federations of the Italian Olympic Committee (C.O.N.I.) have allowed us to determine the importance of meteorological variables and the impact of different time-scales weather forecasts on the general performance for several sports [11,12].

In particular the following disciplines have been analyzed:

- Cycling: road
- Rowing
- Canoe and Kayak
- Athletics: Marathon & Race Walks
- Modern Pentathlon
- Equestrian Sports
- Tennis
- Archery
- Shooting Sports
- Triathlon
- Sailing.

The analysis of the data extracted from the focus groups, showed that all sports studied are strongly influenced by the following meteorological variables:

- Temperature
- Humidity
- Wind.

Some sports, and among them we can mention tennis, cycling and, in general, all shooting disciplines, are also influenced by rain and fog.

It was also observed the high impact that long-term weather forecasting can have on all sports considered. This analysis leads us to believe that all major sporting events (Olympics, World Championships) are to be considered as "situ-specific". It follows that athletes, coaches and technicians can use a careful climatological analysis to finalize the sports training well in advance from the date of the event.

Finally, it was evaluated as the weather forecast at different time's term can be used to improve sports performance.This further analysis confirms that the sports training of an athlete should be considered as a complex system where only the correct interaction between information from different sources can lead to the achievement of excellence's performance.

The performed analysis clearly shows that both meteorological and environmental parameters can have a significant impact on the sports performance for outdoor events. Therefore the assessment methodology presented can be considered as innovative for applied sport research.

It follows that the Performance Analyst should develop relevant competences needed for conducting an integrated data analysis, taking into account the environmental parameters as well.

Moreover the Performance Analyst have to take care of the results' communication of this integrated performance data analysis to the coaches through understandable and meaningful messages.

From the focus groups it was concluded that, in the sports performance analysis, need to be addressed, as well as the well-known areas of Performance Analysis, which are:

- "Motion Analysis "
- "Match and Timing Analysis"
- "Notational Analysis"

also two new areas, namely:

- "Rule Analysis"
- "Environmental Analysis"

These considerations are in agreement with innovative researches carried out on the Team Sport [13,14], on the cycling [9], on the water sport [15] as well as in the winter sports [3,16].

Therefore National Sports Federation should pay particular attention to train these specific competencies in order to create sports operators that can fill the role of Performance Analysts with the necessary awareness. In addition the technicians will need a specific and continuous education in Climatology and Weather Forecasting allowing the achievement of the fundamental knowledge in the field of environmental analysis.

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