The aim of this study was to investigate the trend of high level swim performance in the last twenty years to observe the results of the introduction of new kinds of race swimsuits on performance. Two kinds of suits were considered, those with more percentage of body coverage used since 2000, and the polyurethane swimsuits, introduced at the beginning of 2008. Winners’ times in short and long course F.I.N.A. World Championship and Olympic Games from 1991 to 2009 were analyzed. Times of long course World Championships and Olympic Games were brought together and compared to see if any difference resulted. World records’ trend was analyzed from the ‘80s to the end of 2009, even to see gender’s differences. Finally, access times to Olympic finals and mean times performed in these races were recorded. Data were taken from official timing websites. The analysis shows that the swimsuits strongly determined the performances during the last twenty years. Great improvement was noticed in correspondence with the introduction of the two kinds of swimsuits in all the different analysis performed, with no gender’s differences. The extent of this improvement is more evident for the suits with polyurethane technology and regards all the swim specialties.

Keywords: swimming, performance improvement, swimsuits
Introduction

In the last twenty years swimming World changed radically after the introduction of new race swimsuits that determined a great improvement at every level of competition. Many polemics followed, not only in the swimming environment, about the legality of the use of these swimsuits, with regard to the ethic and pedagogical aspects correlated to their use. This study was conceived to analyze and compare objective data, understand the trend of the performance and finally make the situation clearer.

Since Sydney 2000 Olympic Games swimmers have been allowed to wear swimsuits with particular fabric’s manufacture and more percentage of body coverage that gave them a drag reduction and let them obtain extraordinary results in race.

Studies performed on full-length suits proved that they reduced passive drag and caused the reduction of swimming energy cost and the consequent performance’s improvement (Chatard and Wilson, 2008; Mollendorf et al., 2004; Rogowski et al., 2006; Starling et al., 1995). Maximal swimming performance depends on the interplay between biomechanical and bioenergetic aspects (Barbosa et al., 2009), the optimization of these factors through the use of more efficient swimsuits lead up to the improvement of high level swim performance. Benjanuvatra observed that this kind of suits provides no additional buoyancy benefits (Benjanuvatra et al., 2002). Performance’s improvement was immediately clear (Shahbazi et al., 2008), so the diffusion of these new racing suits was very fast (Matsunami and Taimura, 2008).

Since February 2008, during Manchester F.I.N.A. World Championship (25m), swimmers bound to Speedo began to use new race swimsuits manufactured with polyurethane technology. The potential of the new suits was evident, indeed, in the course of the meeting, 18 World records and 24 Championship records were broken, extraordinary numbers for a single edition of the Championship. Then, after others considerable World record breaking, the run toward this new technology started. Indeed, other firms began to study new products equally competitive manufactured with polyurethane technology. Swimmers began to search the swimsuit that could give them the most possible advantage for their specialty. And, at the same time, International and National Swimming Federation were trying to control this phenomenon and to give indications about allowed swimsuits and manufacturing rules. For exempla, the Italian Swimming Federation forbade the use of these new swimsuits for the Olympic qualification
to Beijing 2008 (to preserve equality in the first competitions, when the polyurethane suits were not available for everyone) and for the younger athletes (not to damage the sport pedagogical aspects). At international level, the F.I.N.A. (Fédération Internationale de Natation) played a crucial role in the determination of which specific suit could be used and which not, in official competitions. Indeed, after several scientific tests performed to determine swimsuits’ features and to measure the advantage that they could give to the swimmers, F.I.N.A. had to give the approval to the suits that could be used in race without incurring in disqualifications. Through numerous meeting between F.I.N.A.’s delegations, producers and scientist, the list of approved swimsuit was published at first on 05/06/09, and then on 19/06/09 in revised version. Swimsuits on the list could be used in official race and permitted to confirm the record performed wearing them. The list, in force till 31/12/09, comprised several kind of suits (classic, full–knee, full, pants–short e pants–long). Each firm developed a different product with the same grassroots technology. Every suit has so different features and could be competitive in different ways. Consequently, the swimmers could choose the swimsuit more comfortable and more suitable for their own discipline. Nevertheless, there were general manufacturing features in common in all the different kind of swimsuits.

The new generation swimsuits were manufactured with a new material, composed by overlapping panels predominantly of polyurethane. According to the producers, the swimsuits were lighter, more resistant to chlorine, more water repellent and with faster drying than normal racing suits. They had been studied to minimize drag forces (friction drag, pressure drag and wave drag) in order to reduce the swimming energy cost and improve in this way the performance. Seams and zips had been removed or refined in order to have a smoother material, without interruptions. Had been introduced even areas with differentiate compression on the swimmer’s body in order to reduce the movements of soft subcutaneous tissues that make the drag increasing. In the models not integrally manufactured with polyurethane, this material was used only in specific shares, expressly studied to have a drag reduction. Producers suggested performance improvement percentage close to 10% with regard to the full-length suits.

Drag reduction seemed to be the cause of the performance improvement resulting from the introduction of new generation swimsuits. The attention to materials and to details in manufacturing phases, for example the improvement of the seams, lead to optimization of compression and to a drag reduction, with the consequent improvement of the performance (Starling et al., 1995). Kainuma hypothesized that performance improve-
ment might be caused by the compression that the swimsuit makes on athlete’s body, that might improve the anaerobic glycolysis system through the suppression of peripheral blood circulation (Kainuma et al., 2008). This hypothesis could explain improvements on short distances, but not the World record breaking occurred in all the disciplines and distances. It was notices that the performance improvement regarded mainly start, turn and arrive phases, with no significant improvements in the central part of the lap (Shahbazi et al., 2008).

Since the first of January 2010 is forbidden to use new generation racing swimsuits with polyurethane. F.I.N.A. drew up the new list of allowed suits, which included only shoulder-to- knee swimsuits with a hole on the back for women and waist- to- knee suits for men.

Methods

To perform this analysis winners’ times in short and long course F.I.N.A. World Championship and Olympic Games from 1991 to 2009 were gathered. Data were analyzed to evaluate the trend of the performance in the different competitions. Times of long course World Championships and Olympic Games were brought together and compared to see if any difference resulted. World records’ trend was analyzed from the ‘80s to the end of 2009, in order to evaluate the periods and the frequency of World record breaking, in regard with the introduction of new kind of race swimsuits. Data were observed even to see eventual gender’s differences in World breaking trend. Finally, access times to Olympic finals and mean times performed in these races were recorded, in order to have a general valuation of swimming movement not only in relationship with the best Word performances. Data were taken from official timing websites.

Results

Short course F.I.N.A. World Championship

In the majority of the competition program occurred a considerable performance improvement in correspondence with the introduction in 2000 of full length swimsuits and then, in 2008, of polyurethane swimsuits. In 2000 the improvement of performance didn’t occur in only few disciplines, in which the specialists of the distances were absent or had been performed excellent races in the previous editions of the Championship. Nevertheless, in all the disciplines and distances occurred a performance improvement with the introduction of polyurethane swimsuits in Manchester edition in 2008.
Long course F.I.N.A. World Championship

In the performance trend was noticed an improvement in the majority of the disciplines, both masculine and feminine, in correspondence with the introduction of full-length swimsuits. Then a performance stabilization occurred until the introduction of polyurethane swimsuits. For male made exceptions 400 and 1500 crawl, because of the great performances of Thorpe and Hackett in 2001, and 400 individual medley, in which there was no significant improvement neither with the introduction of polyurethane swimsuits. For women occurred a great improvement either in 2000 than in 2008. The trend of the performance in this case had not a linear course even before the introduction of the full-length suits because of the extraordinary exploit in Rome 1994 of the Chinese swimmers, who won 12 disciplines on the 16 in program, always with remarkable times.

Olympic Games

Also in the analysis of the Olympic performance was noticed an improvement of the winners’ times in correspondence with the introduction of full-length and polyurethane swimsuits. The trend of the performance with the racing swimsuits analyzed resulted not very definite because of the normal data slenderness between Sydney 2000 and Beijing 2008 Olympic Games. In countertrend resulted the women 200 backstroke. In this discipline times tended to increase instead of decrease until the introduction of polyurethane swimsuits, so the improvement resulted very evident.

Long course F.I.N.A. World Championship and Olympic Games

Data of long course F.I.N.A. World Championship and Olympic Games, the more important competitions in the swimming international calendar, were brought together and compared to see if any difference resulted. Times performed during the Olympic Games tended to be on average better than during the World Championship. Performance trend is similar between male and female and is characterized by a linear improvement until the introduction of the full length swimsuits in 2000, when is noticed a clear amelioration. Then is observed a settlement of performance that ended only with the advent of the new generation swimsuits, that caused a sudden and generalized improvement of the times obtained. The exceptions are the same observed in the separated data analysis, as the Thorpe and Hackett’s great performances or the anomaly of the Chinese swimmers in Rome 1994, as could be seen in the figures reported as trend’s examples.
Fig. 1. Performance trend of 50 m free style in Long Course F.I.N.A. World Championships and Olympic Games. The competitions in correspondence with the introduction of new racing swimsuits are indicated with the asterisks.

Fig. 2. Performance trend of 100 m free style in Long Course F.I.N.A. World Championships and Olympic Games. The competitions in correspondence with the introduction of new racing swimsuits are indicated with the asterisks.
Fig. 3. Performance trend of 200 m free style in Long Course F.I.N.A. World Championships and Olympic Games. The competitions in correspondence with the introduction of new racing swimsuits are indicated with the asterisks.

Fig. 4. Performance trend of 400 m free style in Long Course F.I.N.A. World Championships and Olympic Games. The competitions in correspondence with the introduction of new racing swimsuits are indicated with the asterisks.
Fig. 5. Performance trend of 1500 m free style men and 800 m free style women in Long Course F.I.N.A. World Championships and Olympic Games. The competitions in correspondence with the introduction of new racing swimsuits are indicated with the asterisks.

World Records
The trend of World breaking records during the last around twenty-five years is similar between male and female. Both of them had great improvements in correspondence with the introduction of new racing swimsuits (either in 2000 and 2008). Not every record was broken in 2000, but all of them fell since 2008 with the use of polyurethane swimsuits. Make exception the Hackett’s World record in 1500 crawl that resists even if achieved with a full-length swimsuit. As it appears from data, in the last two years is not extraordinary only the number of different specialties in which a World record has been broken, but even the frequency in which this new records had been subsequently filed by different swimmers.

Olympic Finals
Data show that in all the specialties and distances included in the swimming program, for both masculine and feminine gender, a drop in the time access to finals and in the mean times performed in them occurred.
This indicates a general improvement of the swimming environment, not only of the best performance, and the drop of the differences between athletes.

**Discussion**

The purpose of this work was to analyze the high level swimming performance to evaluate how much the introduction of full-length and polyurethane swimsuits influenced its trend. From data clearly resulted that swimsuits had a determinant influence on performance improvement. Great improvements occurred either in 2000 or in 2008 in every important international competition and in the absolute performances represented by World records. It was noticed that the improvement didn’t concern only top performances but the all swimming environment, which was affected by an extraordinary development so as to reduce differences between athletes. This could be noticed in the frequency of World records breaking by different swimmers, by the drop of access times to Olympic finals and mean times performed in these races.

In could be interesting to continue this analysis to observe the performance trend now that the use of polyurethane and full-length swimsuits is forbidden.

**References**


