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Original Article

Long term effects of doping in sporting records: 1886-2012

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ABSTRACT

Hermann, A. & Henneberg, M. (2014). Long term effects of doping in sporting records: 1886-2012. *J. Hum. Sport Exerc., 9*(3), pp.727-743. Best life times of top athletes, Olympic records, world records, and any doping information were collected from the IOC, IAAF, WADA and national anti-doping associations. About 1560 records of male and female athletes in 22 disciplines of summer and 4 winter sports were collected. Data were analysed for long-term effects of doping using non-linear regression techniques. Comparisons were made of pre-1932 records (when steroids became available) and post. Analyses were repeated using 1967, when widespread use of doping was formally acknowledged. After these dates records in a number of disciplines did not improve as predicted by extrapolation of pre-doping years results. Averaged best life records for 'doped' top athletes did not differ significantly from those considered 'non-doped'. Even assuming that not all cases of doping were discovered, the practice did not alter sporting records as commonly believed, Doping may be damaging image of sports without benefitting results. **Key words**: DRUGS, PERFORMANCE ENHANCING SUBSTANCES, TOP ATHLETES, TRACK AND FIELD, WINTER SPORTS

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INTRODUCTION

Doping is one of the big three scourges of modern day sports. With the advent of professional sports the issue of doping has perhaps become even more prevalent than ever before. The consequences of such actions are no longer confined to the sporting arena. The effects of doping in modern sports are far and widespread, encompassing not only the athletes and sporting teams involved but also sponsors, fans and one may say, greater society as a whole. Yet, despite this, or perhaps because of this, doping is still a major concern. It has been suggested by some, such as David Howman, director general of the World Anti Doping Agency (WADA), that current doping statistics do not fully represent the true extent of doping (Cycling News, 2011). That the suggested approximately 2% of positive tests (WADA, 2010) do not by far represent the actual prevalence of doping agent usage. As suggested by Lentillon-Kaestner and Carstairs (2010:342) and other authors, the true extent of doping is difficult to know due to what they term 'the law of silence' (Noakes, 2004; Simon, Striegel, Aust, Dietz, & Ulrich, 2006). Whilst it is generally accepted that the use of chemical substances in sports is by no means a new issue (Noakes, 2004), it does appear to be the case that structured systematic doping may not have begun until the 1940's. This in turn led to the eventual decision by the International Olympic Committee (IOC) to introduce anti-doping legislation in 1964 (WADA, 2012). Yet despite this, there have since been some of the largest cases and suspected cases of systematic state-sponsored doping; East Germany (Franke and Berendonk, 1997), China (Jeffery, 2008), US Postal Cycling Team (USADA, 2012) and suspicion is now emerging centred on the United States. It can still, however, be said that it was the 1930's that saw the beginning of doping with the potential to truly alter results, the isolation and creation of steroids saw to this. As such if one therefore takes this approximate date as the threshold separating 'clean' sport from doping supplemented sport, an interesting trend arises.

Numerous sources indicate that current doping detection rates seriously underestimate the actual extent of doping (Cycling News, 2011). Literature on success rates of tests and their sensitivity suggests the actual detection may in fact be below 5% in some cases, while typically it is below 50% (Erotokritou-Mulligan, et. al. 2007; Graham, et. al., 2008). These figures indicate that the current lists of records contain at least some achieved with the use of undetected doping. Therefore statistical analysis of official records should reveal at least part of the influence doping has on sport achievements.

Moreover, an early paper by Fowler et. al. (1965), went as far as to suggest that the actual act of doping will not improve an athlete's results; that any such improvement may be caused by increased motivation and training brought on by doping not the doping substance itself. In a similar vein a recent paper by Hermann and Henneberg (2012) demonstrated, through analysis of 100m sprint results, that doping as practiced today, may not be resulting in the desired outcomes for athletes choosing to partake in the practice of doping. There are a number of authors debating the performance enhancing effects of several doping agents (Saugy et al., 2006; Liu, Bravata, Olkin, Friedlander, Liu, et.al., 2008).

This would seem to counter the research by a number of individual authors which seems to indicate that individual cases of doping improve an athlete's results (Bhasin et al. 1996; Noakes, 2004), therefore the idea developed in the paper by Hermann and Henneberg (2012) is here further explored to determine the extent in different sports.

Due to the illegality of the practice there are no official statistics showing how many people actually engaged in doping and how this doping influenced top results (Noakes, 2004). We know from work of sports scientists that the injection of some doping substances certainly improves performances in individual

instances (Bhasin, et al. 1996). And therefore we now wanted to detect effect of doping on top results by regressing these results against time during periods in which doping became available and possibly widespread as indicated by numerous discoveries of late. So, an analysis of pre and post doping era was performed to see what effects doping practices have on top results.

The aim of this paper is therefore to attempt to determine if the effects of doping can be seen in historical results and to determine the extent of the conclusions of the paper by Hermann and Henneberg (2012). The purpose being 1) to establish the potential impact widespread doping has on results in an individual sport and 2) to determine if any sports are for the most part doping free. The benefits of such research are that it will aid in an improved understanding regarding how widespread doping is. Furthermore perhaps this research will aid policy makers in formulating fair and appropriate anti-doping legislation, specifically adjustable for specific sports.

MATERIAL AND METHODS

Data for this research were collected relating to a number of Olympic sports in both the Winter and Summer games for both female and male athletes. Information gathered related to gold medals, Olympic records and world records. For each discipline record times or distances as appropriate and years the achievements were made, were noted. The years being independent variable, and results being the dependent variables. Furthermore, information pertaining to the personal best times/distances and year's results were set of top athletes in a number of disciplines were collected. All these data were obtained from websites including the International Association of Athletic Federations (IAAF) (2011), International Olympic Committee (IOC) (2011) and each sports respective governing bodies' sites. This was then cross referenced through numerous additional sources such as various national anti-doping agencies and the World Anti Doping Agency. The disciplines studied in this paper are listed in table 1.

Table 1. *Sporting events considered in the paper*

Sporting Events	
100m sprints	Decathlon
4x100m relay	High jump
1500m	Pole vault
3000m	Long Jump
10000m	Triple jump
100km	Shot put
3000m steeplechase	Javelin
Marathon	Hammer throw
110m hurdles	Discuss
100m hurdles	500m Speed skating
400m hurdles	5000m speed skating
20km race walk	10000m Speed skating
Heptathlon	Ski jump

A wide range of disciplines were selected in order to provide a means to eliminate biases pertaining to any particular singular discipline. Such biases may originate from scoring systems and time measures specific

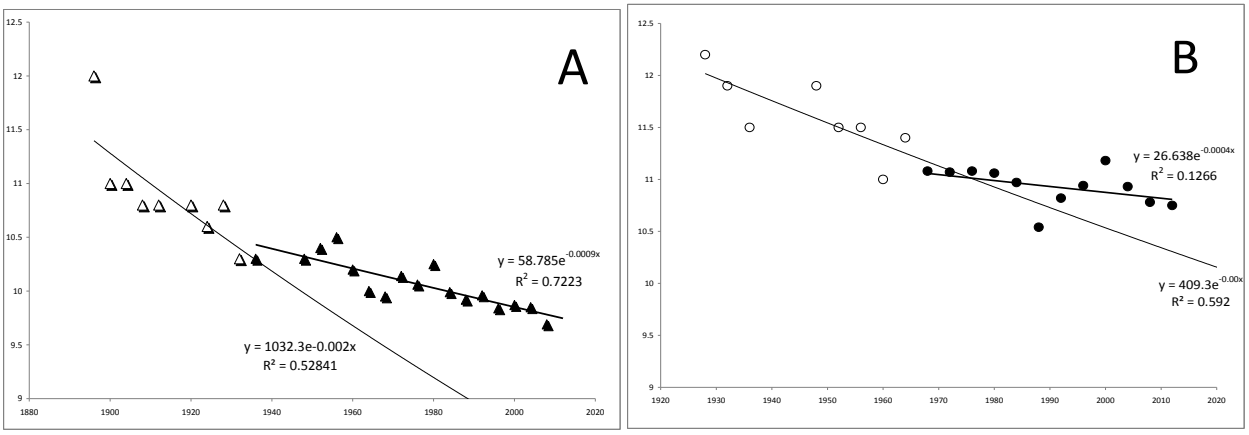
for a discipline. All information used in this research is publicly available, and therefore, there was no need for any ethical clearances.

Data for each discipline, separately for males and females, were analysed using Microsoft Excel™. Scattergrams of records against dates achieved were produced and a number different regression models fitted. Significance of results was tested at p=0.05. Regression lines fitted to data for the pre doping era were extrapolated until 2012 in order to provide a prediction of how records should change over time were doping not available. Actual records for post doping era were then compared to those predictions by means of fitting to them separate regression models. Values of slopes and intercepts for the two separate regression lines were compared for statistical significance using 95% confidence intervals. Pre and post doping points were either 1932 or 1967 as explained in the introduction, which depended on quality of information available. Moreover, as outlined above, before 1932 athletes were all but unable to engage in systematic doping as no substances were available; however this is no longer the case. Now it is known that some athletes do indeed dope as they are being caught. Therefore the more recent results analysed certainly included the results of dopers. The relationships between the results and the years were observed in an attempt to see if the years after the introduction of doping had better results.

In relation to top athletes in each sport, best times were plotted separately for those athletes with no doping involvement and those with known doping agent involvement (figures 5A to 5D). Athletes were categorised as 'doped' if they fulfilled at least one of three criteria: Firstly the self-admission of doping agent usage, secondly, a doping related conviction, thirdly the confirmed detection of known doping agents in their bodies irrespective of whether doping convictions were later received. Regression analysis was used to discover changes through time while t-tests were applied to find the significance of differences between means of doping and non-doping athletes.

Furthermore, analysis was performed with regards to the time since the current world record was set versus the date of the analysis, that is 2011, and subsequently to the date the previous world record was set (figure 7A and 7B). This was performed in order to understand how quick the progress of achievements in a given discipline may be. Therefore, in the era of doping we sought to find if there is any important improvement of results, we realise there is a multitude of confounding factors involved, but if the result did not improve then this demonstrates the minimal impact of doping.

RESULTS



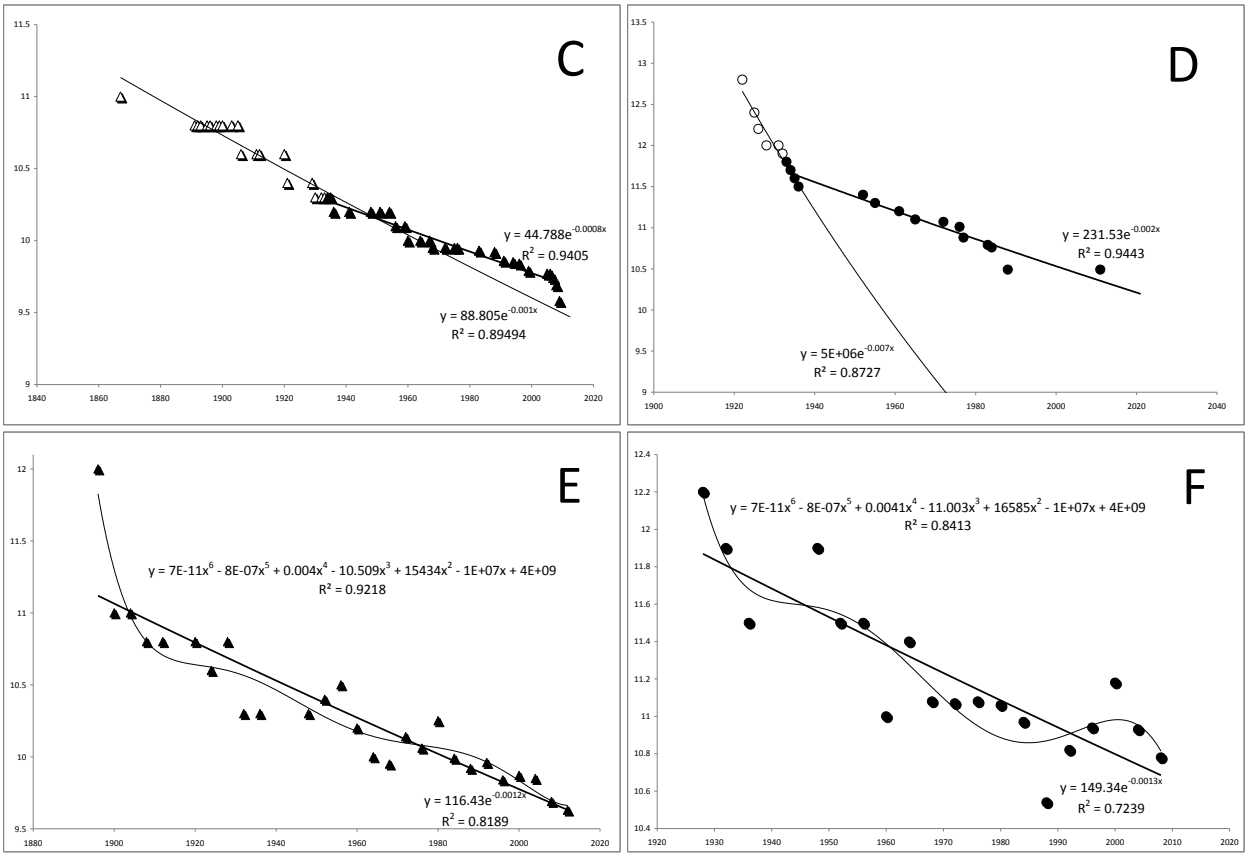


Figure 1. *100m Sprint, Olympic gold medal times pre and post 1932 vs years times set compared for males (A) and pre and post 1967 for females (B); world record times pre and post 1932 vs years times set compared for males (C) and females (D); Olympic gold medal Polynomial trend for males (E) and females (F)*

As can be seen in figure 1A, by using 1932 as a date for the commencement of systematic or at least widely practiced doping usage, one observes an exponential trend line extrapolation of pre-1932 100m sprint Olympic medal times well above that of the current fastest Olympic gold medal time or even world record times. It was not reasonable to plot Women's 100m sprint Gold Medal Times as the women's 100m sprint event only began in 1928, as such reliable conclusions could not be drawn from such a graph. However as can be seen in 1B, when utilising 1967 as the year of comparison results obtained, whilst much less pronounced, do indicate a similar trend.

Figures 1C and 1D demonstrate similar results, an exponential trend line extrapolation of pre-1932 world record times in the 100m sprint provides similar results (particularly post 1960's). When one then collates all the data irrespective of year and attempts a trend line analysis the results as seen in figures 1E and 1F are obtained. As can be seen in Figures 1E and 1F rather complex polynomial trend lines (6th order) are required to fit the gold medal results as obtained in both the men's and women's 100m sprint. When compared with a more simplistic exponential trend line the results differ markedly. Similar if not more pronounced results are obtained in other sporting disciplines.

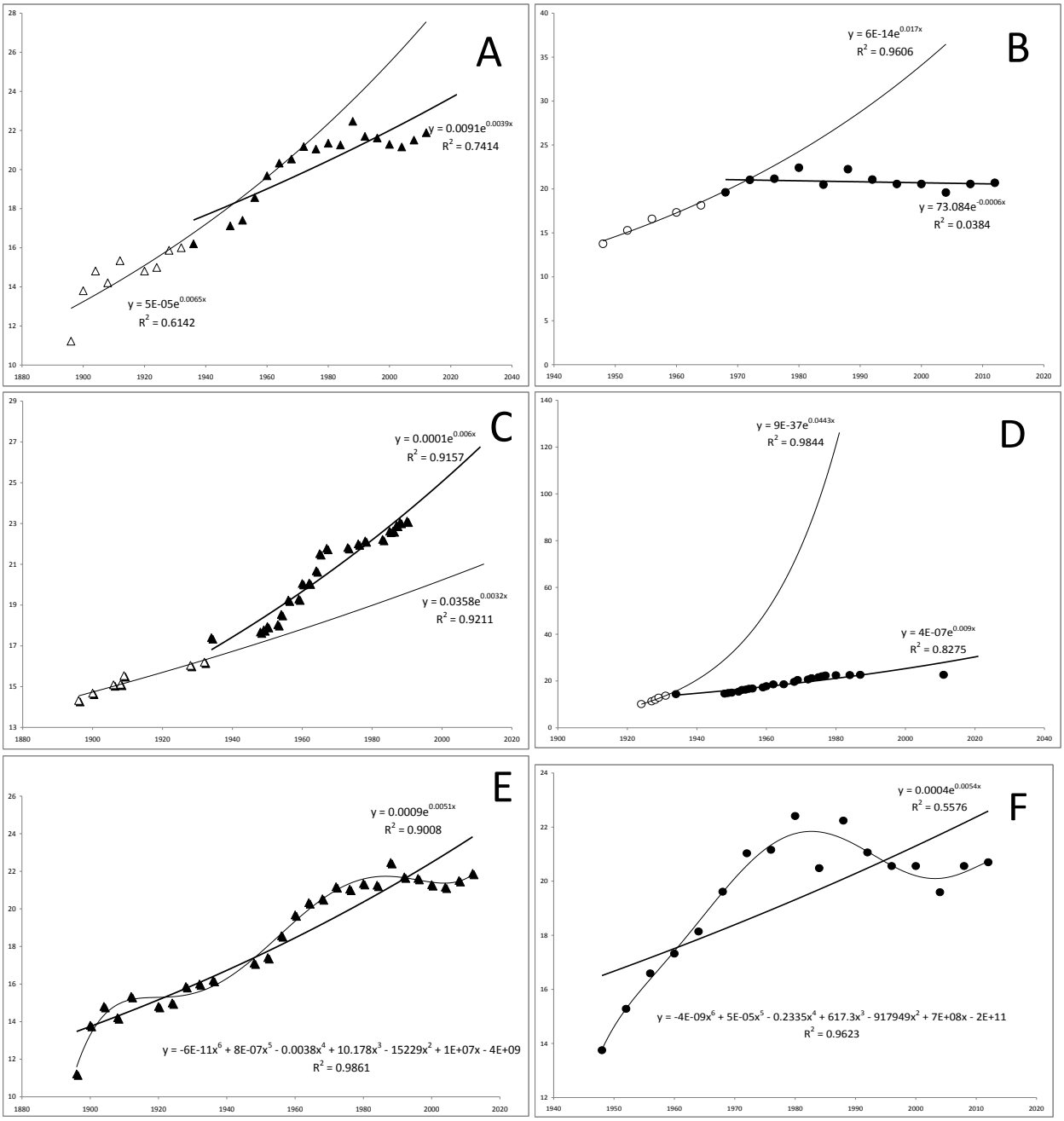


Figure 2. *Shotput Olympic gold medal distances pre and post 1932 vs year distances set compared for males (A) and pre and post 1967 for females (B); world record distances pre and post 1932 vs. year distances set compared for males (C) and females (D); Olympic gold medal Polynomial trend for males (E) and females (F)*

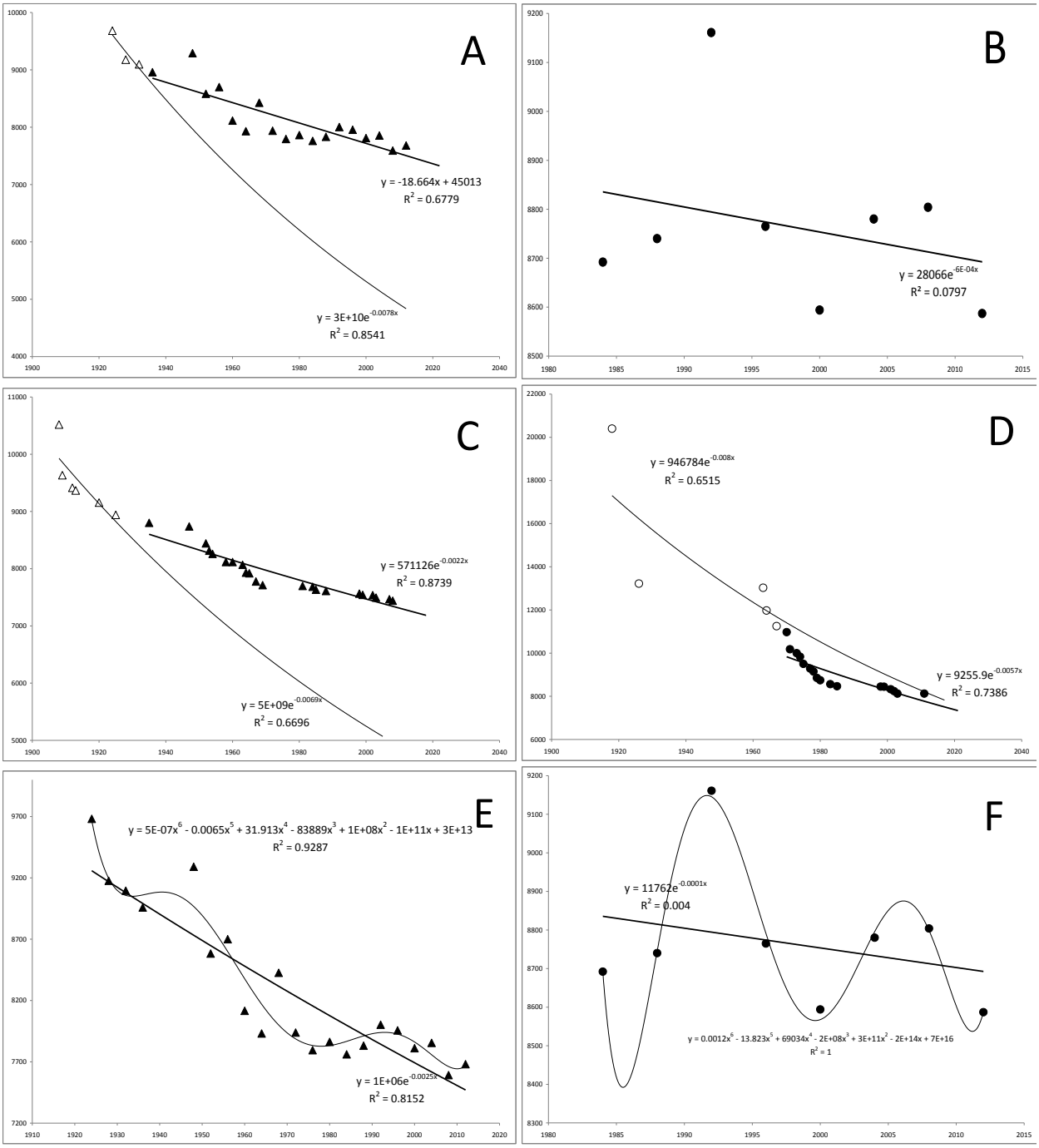


Figure 3. *Marathon Olympic gold medal pre and post 1932 times vs year times set compared for males (A) and gold medal times vs year times set compared for females (B); world record times pre and post 1932 vs year times set compared for males (C) and pre and post 1967 for females (D); Olypmic gold medal Polynomial trend for males (E) and females (F)*

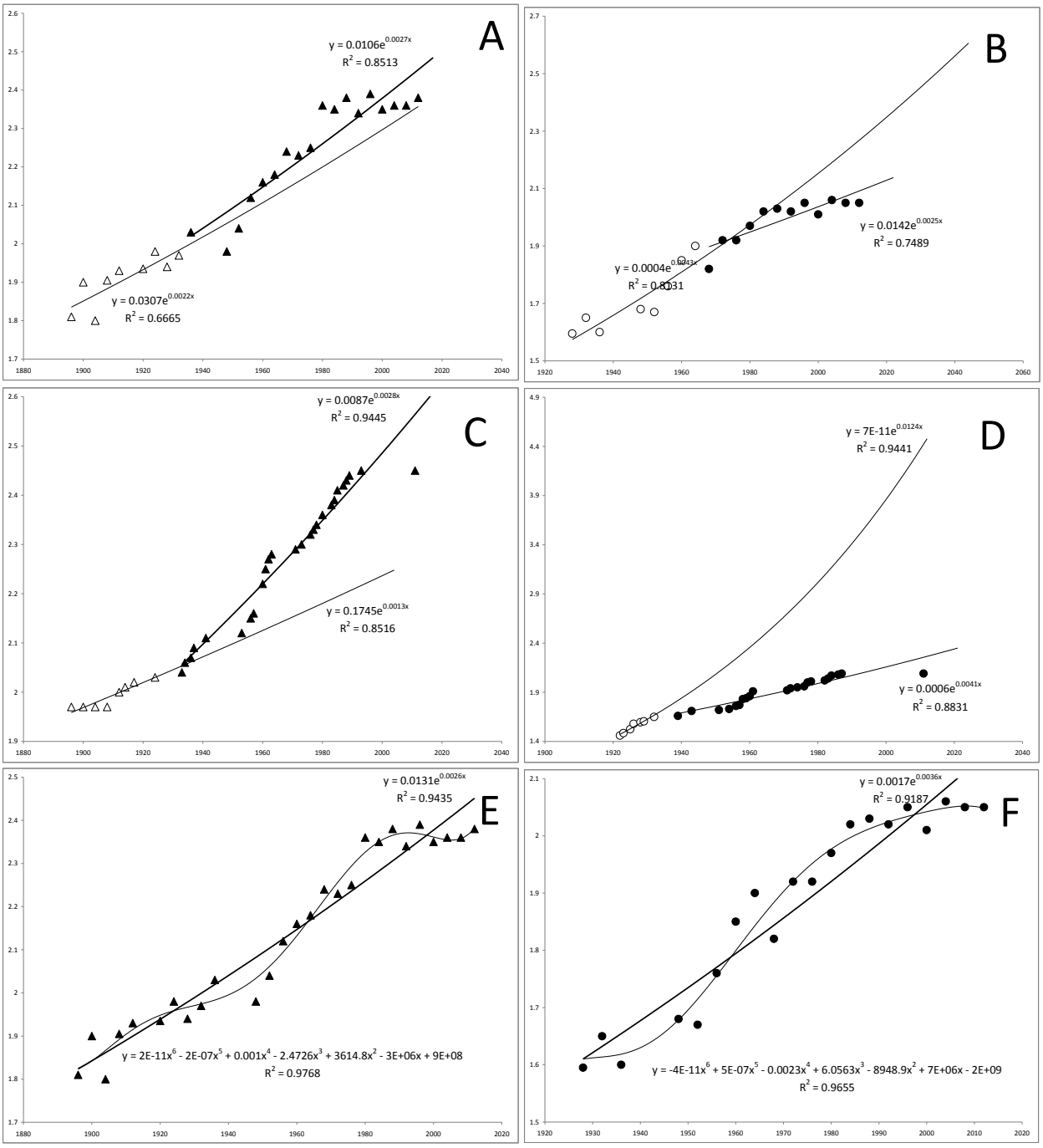


Figure 4. *High jump Olympic gold medal pre and post 1932 distances vs year distances set compared for males (A) and pre and post 1967 for females (B); world record distances pre and post 1932 vs. year distance set compared for males (C) and females (D); Olympic gold medal Polynomial trend for males (E) and females (F)*

As can be seen from figures 2 to 4 with all but the exception figures 2C and 4C both of which are world record figures, similar results seem to have been obtained in a number of very different sports. That is the pre-1932 results when extrapolated would seem to indicate a level of performance above that which is currently being realised in the various sports. Furthermore, the research performed on the top athletes (figure 5) in an assortment of sports, provided similar results.

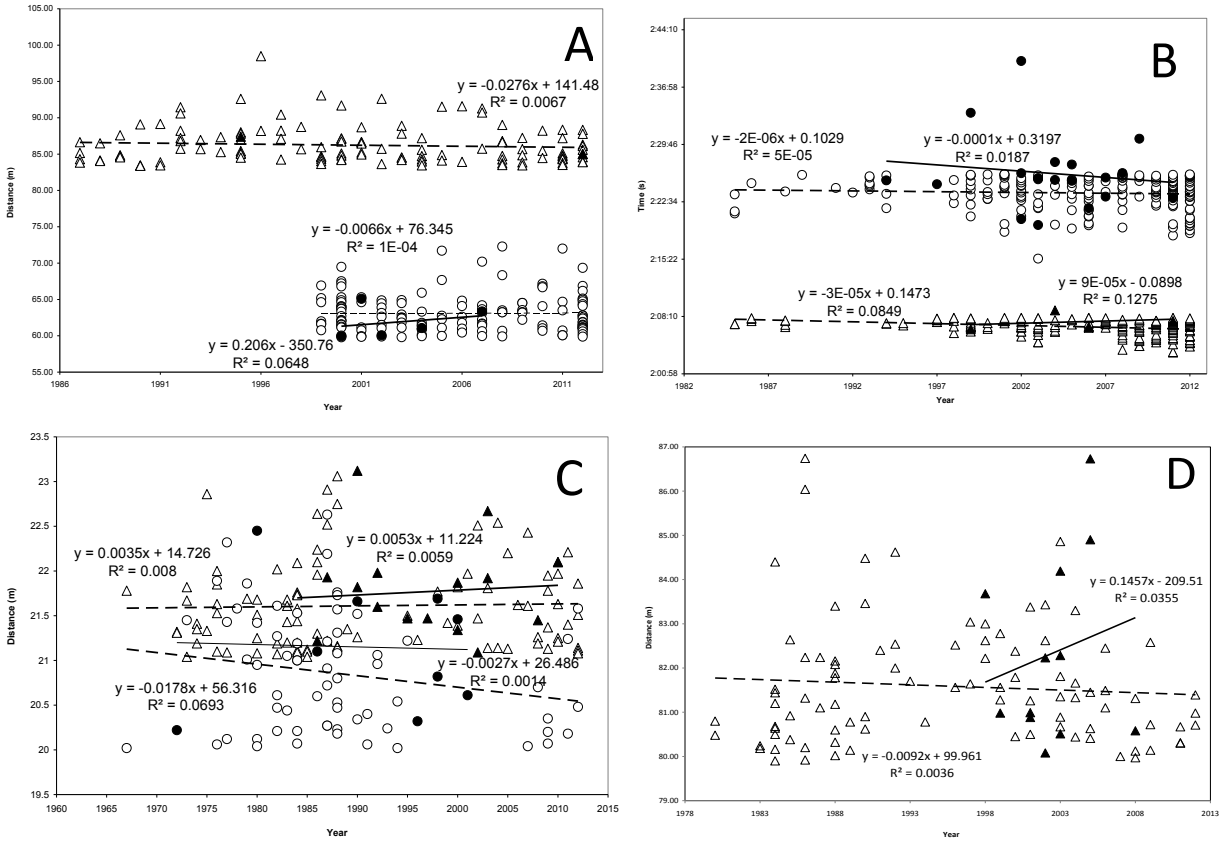


Figure 5. *The personal best results of male and female athletes in summer athletics disciplines; Javelin (A), Marathon (B), Shotput (C), Hammer Throw (D) – closed figures solid lines "doped' athletes, open figures and dashed lines 'non-doped' athletes*

In figure 5D above, it should be pointed out that the 'doped' trend line is not significant and as such does not differ from that of the 'non-doped' athletes. If one however now turns their attention to the winter sports different results are obtained.

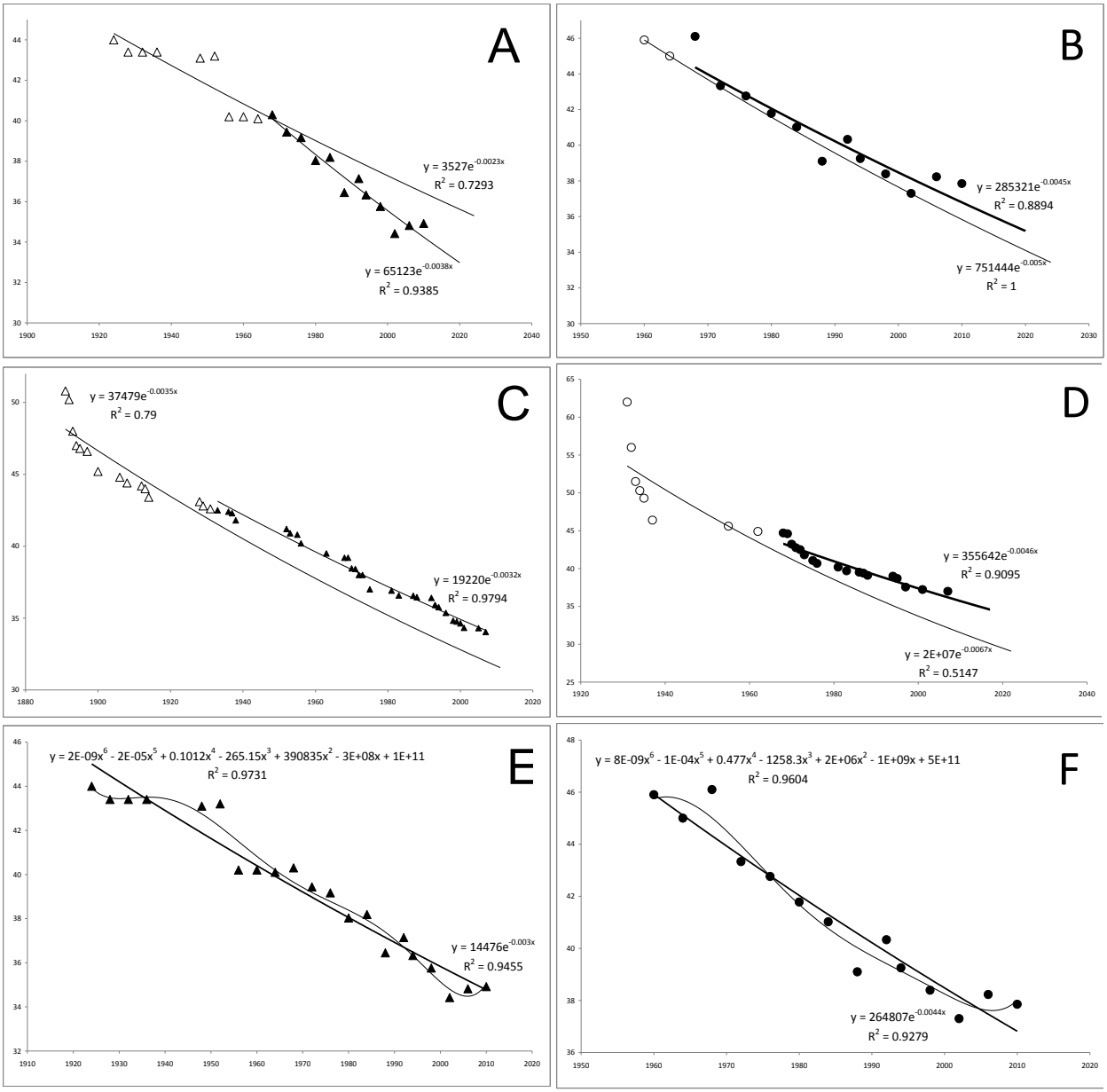


Figure 6. *500m speed skating Olympic gold medal pre and post 1967 times vs year times set compared for males (A) and females (B); world record times pre and post 1932 vs year times set compared for males (C) and pre and post 1967 for females (D); Olympic gold medal Polynomial trend for males (E) and females (F)*

As can be observed from figures 6A to 6D the results obtained in the 500m speed skating discipline since 1932/1967 are considerably closer to those obtained pre-1932/1967. In some cases the results are better than those obtained pre-1932. Similarly figures 6E and 6F show that there is far less difference between the complex and simple trend line analyses. These results can also be observed when one analyses the 10,000m speed skating event, current results are close to the extrapolated results as are trend line analyses.

These results would seem to be verified when compared to figures 7A and 7B. These figures both show that in men's and women's disciplines the winter sports tend to appear further down the list whereas the 'strength' sports appear higher on the lists.

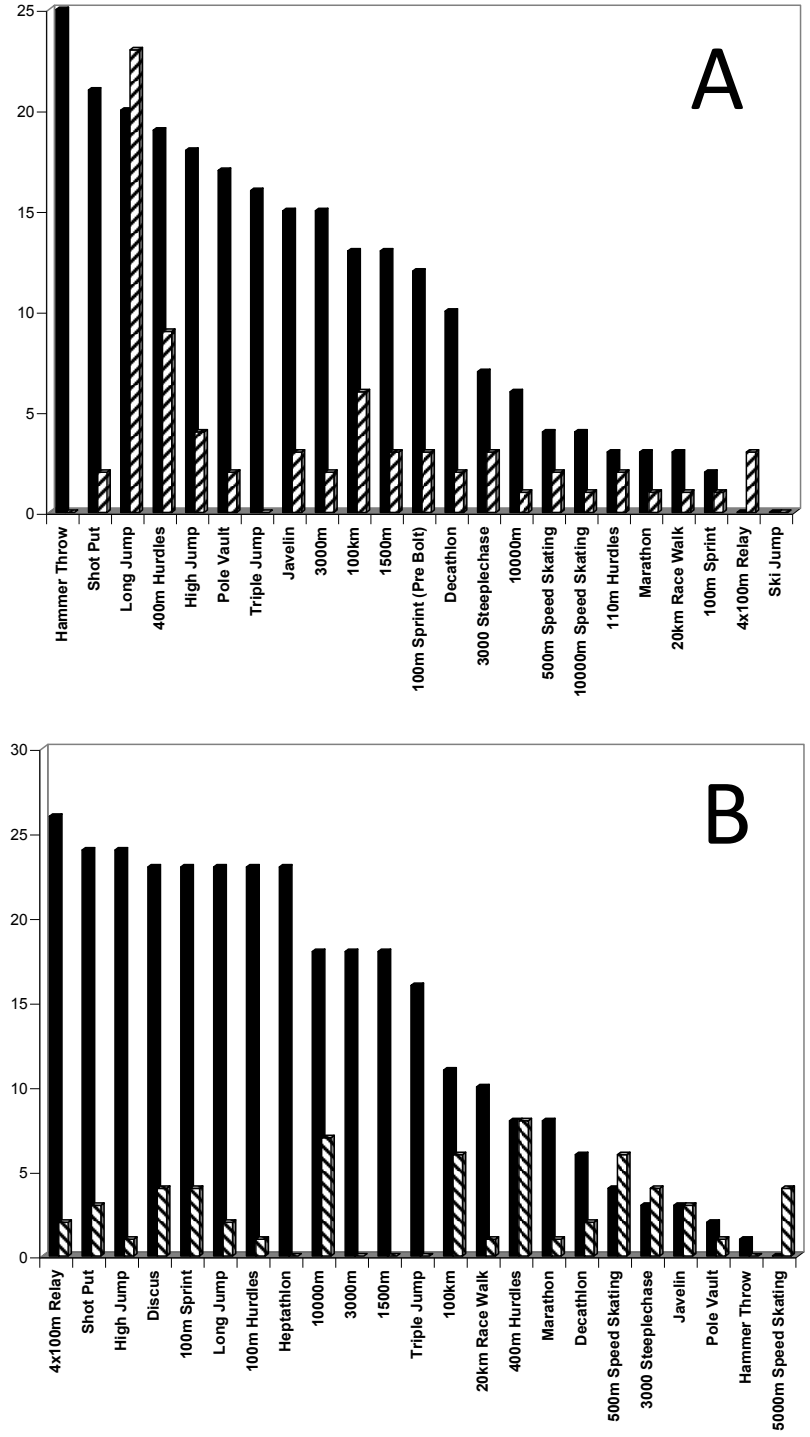


Figure 7. *Years since world record (black) vs. years since previous world record (striped) for males (A) and females (B) in various disciplines; note generally lower values for winter sports*

DISCUSSION

There are two different explanations for the above results. Firstly, what the above results would seem to indicate is that the so called 'performance enhancing' agents utilised by said athletes do not seem to be having the desired effect. Moreover, these results indicate that the use of doping agents may in fact effectively be having a detrimental effect on the athletes; seemingly indicating that 'natural' human abilities would outperform the potentially doping 'enhanced' athletes. This counterintuitive conclusion is particularly supported by the analysis of Olympic gold medal and world record times/distances. Figures 1D, 2B, 2D, 3A, 3C and 4D very clearly demonstrate some rather extreme differences in the extrapolated pre-doping era results vs. the actually achieved post-doping era results.

One would expect to see a gradual decline in times and increase in distances until a human ability limit asymptote is reached at which point unaided/unenhanced improvement would not be possible. It can be said that this is realised for the most part in the winter sports assessed in this paper but not in the summer disciplines. Furthermore, one would expect to see significant improvements in time times/distances set in the modern era over the pre 1930s (or 1960s) predictions for a number of reasons. Firstly the move from amateur to professional sports; this move should have brought with it vast improvements in the performance of athletes, many of which base their whole life on such performance and as such would afford extra effort into the endeavour of improving results. Similarly, the improvements in training techniques and material sciences, each of which are clearly proven to enhance performance (Howartson & van Someren, 2008; Roi & Bianchedi, 2008). Additionally, the 2nd half of the 20th century has seen rapid development in the fields of molecular biology, and as such one could expect enhancements to biological characteristics of athletes, their anatomical structure and physiology many of which may well be considered not to be doping. Moreover, the advancements in scientific monitoring of athletes, structured training and fine tuning of techniques all should add to the improvement of results. Such improvements would seem to be realised to some extent in winter sports. Advancements in wax, ski design, skate structure and technique has resulted in significant and continuous improvementsin some cases.

Why then do the results in summer sports seem to indicate the contrary? There is no continuous improvement to an asymptote. In fact at points, a clear degradation of results can be observed. One such example is the 2000 Olympics gold medal result for the women's 100m sprint, this result is even poorer than the gold medal result obtained in the 1968 Olympics, the first year of doping testing in the Olympics. Similarly, one would expect that the Olympics would be the highlight of most athletes' careers as such it would be expected that an athlete's best results should be obtained at the Olympics. This would seem not to be the case. Whilst it is true that external factors may play a role in a single Olympics, such factors are unlikely to occur at multiple consecutive Olympics. As such it seems that some unknown quantity must be also contributing to the overall trend. One of those contributing factors could be doping. The fact that as can be seen in figures 1F, 2F, 3E, and 3F complex trend lines are required to even begin to ascertain a trend of results would seem to further support this assessment.

Reference to figures 7A and 7B further supports this assessment. Firstly, in both cases winter sports events are in the lower halves of the graphs, and secondly, the so called strength sports (e.g. shot-put, hammer throw etc.) are in the first few places. This would seem to coincide with the perception that winter sports are in general 'cleaner' sports or at least that doping may not be as widespread as in many of the summer sports (WADA, 2010). Furthermore, these results indicate that the strength sports (which would seemingly almost yearly be embroiled with a doping scandal), may have more widespread use of doping agents. Two possible reasons for this phenomenon exist, firstly, that strength sports unlike many winter sports focus on

a primary skill, that of strength; as such any athlete seeking to enhance their performance knows exactly what to target, a singular primary method. Winter sports on the other hand involve a plethora of different techniques and abilities including stamina, endurance, strength, agility, precision to name but a few. This therefore means that any such doping would be much harder to conduct in winter sports in any foreseeably beneficial manner. As such any athlete participating may be more prone to detection due to the assortment of agents needed to enhance multiple skills. Therefore, winter sports athletes may see such action as being without benefit and thus may be deterred from engaging in the practice, or at least engage in it to a lesser degree than in other sports. This would seem to support current statistics in the area of detected doping frequencies, skating and skiing 0.27 and 0.71 respectively vs. athletics and weightlifting 0.78 and 2.42 respectively in adverse analytical findings (WADA, 2010). Therefore, perhaps it can be said that an athlete's decision to dope may be primarily or at least to a large part determined by perceptions, the perception that doping is needed to win (Cycling News, 2008; Cycling News, 2010), the perception that doping helps (Lentillon-Kaestner & Carstairs, 2010), the perception that doping is easy, or the perception that they can easily target specific beneficial skills for enhancement (Lentillon-Kaestner, 2011), the perception that the likelihood they will be caught is less than the likelihood they will benefit (Uvacsek, et. al., 2011), the perception that benefits outweigh the risks (Mroczkowska, 2009) the perception of anti-doping tests detection success rate, the perception that they will get away with any action that there will be no consequences (Piffaretti, 2011) the perception of the extent to which sporting success brings prestige and prosperity (Piffaretti, 2011).

On the other hand there seems to be a possible explanation for the apparent lack of doping in winter sports which may fit in with the very foundations and structure of many winter sports. To elaborate, take the 100m sprint in the summer games, whether an athlete wins is based on their time directly; it is a simple measure of who gets to the finish line first. Many winter sports on the other hand are a combination of time, points systems and courses selected by officials. Take ski jumping for example; it is a combination of distance points based on judge's votes of style, selection of gates by judging panel also plays a role etc. Recent disputes between teams and officials relating to undesirable and/or sudden gate changes demonstrate the changing nature of winter sports courses. Alpine Skiing has similar components, official designed courses which change per run combined with the time factor. Athletes may see doping in such sports as futile sincethere are many other factors that would also need to be manipulated to change results. Once again this may indicate that an athlete's perception of their external and internal environments plays a big part in their decision to dope or not. This conclusion would seem to be supported to some extent by the statistics. WADA statistics on sports with judges voting systems seem to have slightly lower levels of adverse analytical results. Gymnastics are one such example with a 2010 percentage of 0.52%.

Therefore can it not be concluded that perhaps these perceptions need to be broken before any true evolution and progress can be made in the fight against doping. One must, however, say that the question remains are these truly just perceptions? It may be that other factors also contribute to an athlete's decision to dope. Furthermore, are these perceptions widespread in the sporting industries or more so in some disciplines as opposed to others. If so why then do some athletes dope and others not; is it merely personality components such as risk aversion or are there issues of the team setting, such as suggested by Lentillon-Kaestner and Carstairs (2010), or sport specific factors which influence these actions? As such more encompassing industry wide research is needed not focusing on one or two disciplines but the entire sporting domain, incorporating all nations and types of athletes, in order to obtain the true extent of the problem and the source. There are also concerns with the effectiveness of current anti-doping testing practices which appear to be ineffective. It has been stated by numerous sources that current doping

detection statistics do not fully represent the state of doping in sports (Cycling News, 2011). Furthermore, extant literature contains information pertaining to the approximate success rates of doping test or test reliability (Erotokritou-Mulligan, et. al., 2007; Graham, et. al., 2008). These figures suggest the actual success rate of some tests may in fact be as little as 4%, on average it would seem less than 50% would be reasonable to conclude. Admissions of doping by some athletes who had long and prominent careers without ever testing positive to a banned substance further demonstrate the ineffectiveness of anti-doping practices. Persons such as Marion Jones, Tim Montgomery, Andre Agassi, Ken Caminiti, Rolf Aldag, Heike Drechsler, Vitali Klitschko and Bjarne Riis freely admitted to using banned substances during their careers. This may demonstrate that the past state of anti-doping legislation and practices would seem to be in place to simply ease the minds of spectators. This situation may well still continue.

Why then have numerous historical examples of effective performance enhancing practices come to the fore; the German Democratic Republic (GDR) being one such example (Franke & Berendonk, 1997). That is to say there have been examples showing the performance enhancing effects of doping. The answer may well be that in those cases, the doping was officially approved, well-planned and executed with advanced scientific and medical expertise, that is to say it was not random athletes personally selecting doping agents without clear information as to the effects or outcomes. Furthermore, despite this, why does the above analysis show that post 1932 results do not match that of pre-1932 in many disciplines? Should not situations such as that with East Germany have brought the result back to those extrapolated from early results? Whilst it can be observed that there is a subtle influence on results during the periods of these scandals, the impact is minimal and do not influence results to the expected level. This warrants further study, but perhaps it comes down partially to athlete psychology. The psychological state of an athlete is believed to contribute to performance (Vealey, 2001; Hays, Thomas, Maynard & Bawden, 2009). Perhaps some athletes, knowing they are achieving results by means which are unethical, have a subconscious barrier to increased performance, an intangible holding them back... This would therefore assume that athletes are generally ethical and governed by internal checks and balances and that the decision to dope is therefore influenced primarily by external influences such as suggested by Hardie, Shilbury, Ware et. al. (2010), economic or prestige factors or even perceived discipline performance expectation.

From an organisational and marketing perspective, the results in this paper demonstrate a concerning element. If the results obtained since the 1930's are skewed by unreported and undetected doping then it can be suggested that the extent of this practice not only affects athletes and sporting organisations but also spectators as a whole. That is to say, if results obtained from doping are in fact degraded, then this in some cases will be depriving spectators of the sight of top level human performance. In turn this constrained athletic ability may result in some spectators turning away from what they may see as 'boring' sports. So therefore, not only does doping tarnish the names of sports or sporting organisations, but the consequence of this for a sporting organisation or discipline is obvious, reduced revenue from spectators and lower spectator numbers, two components vital to an organisation in modern day sports.

Finally, it can be concluded that the results of this paper further support two key findings by Hermann and Henneberg (2012). 1) Perhaps systematic, scientifically supported doping where all effects are fully known, may aid in improving an athlete's performance, but that 2) perhaps the clandestine nature of modern doping means that athletes are limited in their chances to dope, in the range of substances available and do not have full support of sports scientists and medical practitioners to ensure such results. The consequence of this second point may be use of ineffective doping strategies and perhaps even in some cases harmful with regards to performance in some disciplines. So whilst individual researchers can see individual improvements in results we cannot see this in overall results. These results which show no

obvious improvements can be interpreted only as indicating statistically there was no effect of doping on overall performance. The only explanation is that doping may produce a minor improvement in one aspect of performance but in other areas it may be having detrimental effects, which in turn outweigh the positives. Were doping so successful as popularly assumed and as widespread as recent "scandals" indicate one would observe in the results massive improvements.

CONCLUSIONS

In conclusion, it would seem that the results obtained in the research can be explained by two possible means. Firstly, that there is evidence that doping practices employed by athletes today, may in fact not be helping results even to the extent that the may be harming them. Secondly, that it is possible that doping is far more widespread than previously thought in the sporting industry. If the results obtained since the 1930's are skewed by unreported and undetected doping then it can be suggested that the extent of this practice not only affects athletes and sporting organisations but also spectators as a whole. This research highlights the need for further study into the true amount and causes of doping on an industry wide scale. Similarly, it appeals for changes to the current anti-doping legislation and testing. Finally and perhaps most importantly, this research calls upon the need to tackle the various perceptions held by athletes and sporting organisations as to doping. By tackling these perceptions one may be able to make significant advances into stamping out doping.

PERSPECTIVE

These results may provide a greater understanding that doping does not produce better results, thus potentially altering an athlete's perception of doping.

Furthermore it may indicate that current techniques used to prevent doping are ineffective and doping is more widespread than initially thought.

It questions the motives behind an athlete's reason and decision to dope, and suggests it is based on perceptions to a large extent

Current anti-doping legislation and testing needs revision

Doping may harm organisational revenue in more ways than originally considered

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