Adverse analytical findings in european anti-doping laboratories

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Summary

Objective: To study the prohibited substances detected in all the European laboratories according to their number and regional distribution and their possible correlation with the results of European athletes.

Methods: The statistics from the 20 European laboratories accredited by the World Anti-Doping Agency have been studied for the years 2003-2008 and for the 11 groups of substances.

To assess relationships between the 20 laboratories and the substances, we used a multivariate statistical analysis, a method used for the study and prediction of occupational accidents. An analysis of independence (chi-square) and Haberman Corrected Categorized Residuals were performed establishing the dependence between some laboratories and substances. Minkowski distances of power 3 were calculated to establish groups with similar profiles.

Results: The adverse analytical findings in the European laboratories show a very heterogeneous distribution and we found major differences in the substances detected in different laboratories.

Despite the limitations of the study, the main findings were that the detection of anabolic agents and related substances was associated to laboratories from Central and Eastern Europe (Austria, Prague, Cologne, Poland, Russia and Turkey) and the detection of hormones was associated to Mediterranean laboratories (Rome, Barcelona and Madrid).

Conclusions: There is a close relationship between the results of the strength specialties (weightlifting and throwing) athletes and presence of anabolic steroids and related substances in the countries of Middle and East Europe, as well as between the results from the Mediterranean area laboratories and the use of hormones in cycling.

Having more data, such as substances detected by sports, would allow more precise analysis of doping and taking into account the geographical distribution could help to implement more specific strategies to combat doping.


Key words: Anabolics. Doping control. Epidemiology. Medical statistician.

Hallazgos analíticos adversos en laboratorios antidopaje europeos

Resumen

Objetivo: Estudiar las sustancias prohibidas detectadas en todos los laboratorios europeos según su distribución regional y numérica, así como su posible correlación con los resultados de los deportistas europeos.

Métodos: Se han estudiado las estadísticas de los 20 laboratorios europeos acreditados por la Agencia Mundial Anti-Dopaje en los años 2003-2008 para los 11 grupos de sustancias.

Para valorar la relación entre los 20 laboratorios y las sustancias se ha usado un análisis estadístico multivariable, método usado en el estudio y predicción de accidentes laborales. Se realizó un análisis de independencia (Chi2) y de los residuales categorizados corregidos de Haberman para establecer la dependencia entre algunos laboratorios y sustancias. Se calcularon las distancias de Minkowsky de potencia 3 para establecer grupos de perfiles similares.

Resultados: Los hallazgos analíticos adversos en los laboratorios europeos muestran una distribución muy heterogénea y se encuentran importantes diferencias en las sustancias detectadas en los diversos laboratorios.

A pesar de las limitaciones del estudio, los principales hallazgos fueron que la detección de los anabolizantes y sustancias relacionadas se encontró en los laboratorios de la zona europea central y del este de Europa (Austria, Praga, Colonia, Polonia, Rusia y Turquía) y la detección de hormonas se encontró en los laboratorios de países mediterráneos (Roma, Barcelona y Madrid).

Conclusiones: Hay una intensa relación entre los resultados de los deportistas de especialidades de fuerza (halterofilia y lanzamientos) y la presencia de anabolizantes y sustancias relacionadas, en los países de la zona central y este de Europa, así como entre los resultados de los laboratorios de la zona mediterránea y el uso de hormonas en ciclismo. Tener más datos, como las sustancias detectadas por deporte, permitiría un análisis de dopaje más preciso y tener en cuenta la distribución geográfica podría ayudar a implementar estrategias más específicas para combatir el dopaje.
Introduction

Doping is a big concern for the Sports authorities and governments around the World and, as a result, the World Anti-Doping Agency (WADA) was created to lead the fight against doping through the guidelines of the World Anti-Doping Code. One of the actions is to carry out doping controls through an international network of accredited laboratories with excellent reliability and accuracy of results.

In addition to other actions, such as research, education and close international cooperation, the fight against doping requires a clear understanding of aspects such as the different ways to use the prohibited substances and methods or how to circumvent controls. The so-called “risk zones” include not only the athletes themselves and the characteristics of sports, but also the geographical areas. The World Anti-Doping Code recommends controls taking into account these characteristics.

Successes in sport seem to be related to the resources allocated to it and the number of practitioners. On the other hand, one might think that the adverse analytical finding (AAF) are related to the results and the number of high-level participants in each sport. So, the prohibited substances detected in a laboratory could be indicators of the kind of sports practiced in a region and they could indicate the number of athletes involved.

Europe has half of the accredited laboratories and a high number of doping controls are performed, but there are few studies relating the AAF with certain sports or the regions where they are practiced.

The aim of this work was to study the prohibited substances detected in all the European laboratories (number and regional distribution) and their possible correlation with the results of European athletes. These data could help to implement more specific strategies to combat doping.

Material and methods

We have studied the statistics from the 20 European laboratories accredited by WADA for the years 2003 to 2008 (Table 1).

The groups “Enhancement of Oxygen Transfer” and “Chemical and Physical Manipulation” are not included in the study because data only are available for 2007.

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<th>Stim</th>
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<th>Cann</th>
<th>Anab</th>
<th>Horm</th>
<th>Beta2</th>
<th>Antio</th>
<th>Mask</th>
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<td>1849</td>
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</table>

Stim: Stimulants; Narc: Narcotics; Cann: Cannabinoids; Anab: Anabolic agents; Horm: Peptide hormones; Beta2: Beta-2-Agonists; Antio: Agents with antioestrogenic activity; Mask: Masking Agents / Diuretics; Gluco: Glucocorticosteroids; BetaB: Beta-Blocks; Other: Others.

Table 1. European accredited laboratories. Substances groups and number of adverse analytical finding.
**Statistics**

We used a multivariate statistical analysis, a method used for the study and prediction of occupational accidents\textsuperscript{15,16}.

To assess relationships between the 20 laboratories and the substances found, we used the information showed in Table 1, with data grouped into a contingency table 20x11.

According to a previous study\textsuperscript{17}, an analysis of independence (chi square) and Haberman Corrected Categorized Residuals\textsuperscript{18,19} were performed establishing the dependence between some laboratories and substances.

With this information, a correspondence analysis\textsuperscript{20, 21} was performed to show graphically the relationships between the different forms of the two variables. Data are represented by points, whose proximity means greater affinity. Since the analysis was performed with three dimensions, graphs are presented for dimension 1 with 2 and 1 with 3 to get a fuller picture. Other two statistic techniques have been used from the factorial punctuation: cluster analysis, to establish groups with similar profiles\textsuperscript{22,23} and Minkowski distances\textsuperscript{22} of power 3.

All data were processed with software SPSS 15.0.

**Results**

A descriptive statistical analysis shows an average pattern of substances detected in laboratories (Figure 1), highlighting anabolic steroids with 46%. However, this pattern varies significantly from one laboratory to another (Figure 1).

The chi square value (3877,995) was significant (p<0,0001) as it rejects the hypothesis of independence. So, an association exists between the two variables (laboratories and substances).

The cumulative proportion of inertia in the three-dimensional model was 0.786.

Figures 2 and 3 show the laboratories and substances in the three dimensions, with the four groups established by the cluster analysis and Table 2 shows the Minkowski distances, which provides support for the analysis of the relationships: the lower value for Minkowski distance, the higher association.

According to these criteria, an association of anabolic agents can be observed with Austria (0,099), Cologne (0,170), Czech Republic (0,484) and Poland (0,644). A bit more distant were Turkey (0,800) and Russia (0,691). In the adjacent group Barcelona (0,495), Switzerland (0,419) and Norway (0,453) were the closest.

Concerning the antiestrogenic agents, the laboratories with higher associations were Czech Republic (0,436), Poland (0,612) and Austria (0,533), although only one case was detected.

The laboratories more associated to masking agents were Cologne (0,308) Greece (0,252) and Turkey (0,531). In Figure 2 Cambridge seems to be close to this substance; however, with a different projection (Figure 3) it is not, and this is consistent with the Minkowski distance (1,694).

Stimulants were associated to London (0,395), Belgium (0,5) and Cambridge (0,761). In the same group, narcotics were close to Belgium (0,556) and Cambrige (0,678).

In the adjacent group, beta-blockers were associated with Portugal (0,359), glucocorticosteroids with France (0,343) and cannabinoids with Belgium (0,493), although Belgium was included in the previous group.

![Figure 1. Descriptive statistical analysis showing the average pattern of substances detected in laboratories. Anabolic steroids are the most frequent finding (46,3%).](image1)

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Adverse analytical findings in European anti-doping laboratories

In the last group, beta-2-agonists were close to Madrid (0.176) and a bit more distant were Finland (0.662), Kreischa (0.643), Norway (0.693) and Sweden (0.764). In Figure 3 Belgium seems to be associated to this substance but in Figure 2 it is very far, what is consistent with the Minkowski distance (1.390).

Peptide hormones were associated to Italy (0.488), Barcelona (0.541), Madrid (0.551) and Switzerland (0.606), while Norway and Kreischa were more distant, as shown in Figure 3.

Finally, substances classified as “Others” only were related to Italy, but not very close (0.821).

Table 3 shows the laboratories with the most detected substances and Table 4 allows for the preferential association of substances with laboratories.

Discussion

Few works analyze the results of doping by geographical locations3-7 and some of them refer to controls performed in Olympic Games and other international competitions8-12. In this case, although the work is done in a geographical zone, the results include different countries.

There are works analyzing some sports14,15 or the drug declaration made by the athletes themselves during the sample collecting process16,17 or through a specific survey18.

An overall analysis of analytical findings shows an average pattern of detected substances in the accredited laboratories (Figure 1). Theoretically, this pattern should be repeated roughly in all laboratories. However, the profiles observed are very different.

All accredited laboratories follow identical analytical procedures laid down by WADA19,20, so associations between laboratories and substances can be assessed by Minkowski distances (Table 3).

Stimulants

The laboratories linked to these substances were London (0.395), Gante (0.500) and Cambridge (0.761).

Stimulants are used for various reasons including medical treatment, weight loss and improvement of physical performance21,22. In addition, this group comprises substances as different as meanephedrine, amphetamines or cocaine but laboratories only provide data for the entire group and not for each substance.

So, we can not make any hypothesis about the results.

Narcotics

These drugs do not improve athletic performance23 but they are used as analgesics to continue training, so they are detected mainly in controls out of competition. In any case, it is possible that some athletes are addicted to morphine.

The laboratories more correlated to this Group are Gante (0.556), Cambridge (0.678) and Rome (0.755). It is important to note that there has been only 100 cases of narcotics over this period.

Cannabinoids

Cannabinoids have shown no ergogenic effect and could even be detrimental to athletic performance24. However, they are the third most frequently detected substance with 2066 AAF. Most of the samples show concentrations compatible with consumption in the previous days (late elimination period)25.

Cannabis can be used for relaxation before competition26 by the proven effect it has on the reduction of anxiety27.

The use of these substances could be associated with social habits28 and the night lifestyle in Mediterranean countries.

The analysis of Football (Soccer) should support this hypothesis. In the 166 AAF from 20750 controls performed by the International Football Federation (FIFA)29 there was 85 cannabinoids. 122 of these AAF (73.49%) were made in Europe (UEFA) corresponding to the following countries: France (30), Italy (21), Portugal (21), Belgium (20), Netherlands (8), Norway (10), Turkey (5), Spain (2), Malta (2), Croatia (1), England (1) and Greece (1).

As one might anticipate, these detections were made in the laboratories of Paris (30 from France), Gante (20 from Belgium and 8 from Netherlands), Rome (21 from Italy and 1 from Malta) and Lisbon (21 from Portugal).

This indicates a significant use of cannabis and cocaine in European Football players which is mainly associated with the laboratories with higher correlation (Paris and Gante) and with those with a higher number of detections (Lisbon and Rome).
Anabolic agents

These substances are widely used in sport and they constitute the greatest number of AAF in all reports of WADA. Anabolics are the best known substances to improve performance. Given that this effect is dose-dependent, the use of supra-physiological doses is common and, furthermore, several agents are often used in combination along weekly cycles. These reasons justify their high detection in sport.

Anabolic agents have been widely used throughout the History: The Soviet weightlifters in the 50s, American athletes in the preparation of the Mexico Olympic Games in 1968, American weightlifters or High School Football players. But perhaps, the case with most media coverage was the detection of Stanozolol in the Canadian athlete Ben Johnson in the Olympic Games of Seoul in 1988 or the use of tetrahydrogestrinone by several American hight level athletes.

The laboratories more associated with these substances were Austria (0,099), Cologne (0,170), Switzerland (0,141), Norway (0,153), Prague (0,484) and Barcelona (0,495). The higher numbers of detections in the spatial analysis showed in Figures 2 and 3, a very close relationship is observed between anabolic, antiestrogenics and masking agents and the laboratories of Austria, Prague, Cologne, Poland, Russia and Turkey.

This association is logical. In fact, anabolics are used in combination with antiestrogenics to stimulate the secretion of testosterone, enhancing the anabolic effect, and to counteract some side effects such as gynecomastia. On the other hand, mask agents are used to hide the presence of anabolics.

In view of this regional association, we studied some sports where strength is critical and could be benefitted with the use of anabolics.

Table 2. Minkowski distances between detected substances and laboratories.

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<tr>
<th>Laboratories</th>
<th>Stimu</th>
<th>Narco</th>
<th>Cann</th>
<th>Anab</th>
<th>Hormo</th>
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<td>0,643</td>
<td>0,968</td>
<td>1,034</td>
<td>1,322</td>
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</tr>
<tr>
<td>Cambridge, U. Kingdom</td>
<td>0,761</td>
<td>0,678</td>
<td>1,473</td>
<td>1,492</td>
<td>0,803</td>
<td>1,370</td>
<td>1,465</td>
<td>1,694</td>
<td>2,130</td>
<td>2,411</td>
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</tr>
<tr>
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<td>0,395</td>
<td>0,823</td>
<td>1,318</td>
<td>1,467</td>
<td>1,422</td>
<td>1,953</td>
<td>1,634</td>
<td>1,394</td>
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<td>1,095</td>
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<td>0,725</td>
<td>0,517</td>
<td>1,193</td>
<td>1,260</td>
<td>1,094</td>
<td>0,252</td>
<td>1,238</td>
<td>0,778</td>
<td>1,566</td>
</tr>
<tr>
<td>Rome, Italy</td>
<td>0,898</td>
<td>0,755</td>
<td>0,803</td>
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<td>0,488</td>
<td>0,901</td>
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<td>0,826</td>
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<td>1,522</td>
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<tr>
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<td>1,172</td>
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<td>0,812</td>
<td>0,693</td>
<td>0,986</td>
<td>0,806</td>
<td>1,254</td>
<td>1,250</td>
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<td>Lisbon, Portugal</td>
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<td>1,695</td>
<td>0,764</td>
<td>0,847</td>
<td>1,593</td>
<td>1,528</td>
<td>1,421</td>
<td>0,582</td>
<td>0,980</td>
<td>0,359</td>
<td>1,970</td>
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<tr>
<td>Moscow, Russia</td>
<td>1,349</td>
<td>1,733</td>
<td>1,571</td>
<td>0,691</td>
<td>1,546</td>
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<td>0,624</td>
<td>2,102</td>
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<td>0,541</td>
<td>0,819</td>
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<td>0,856</td>
<td>1,553</td>
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<td>0,980</td>
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<tr>
<td>Madrid, Spain</td>
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<td>0,551</td>
<td>0,176</td>
<td>1,532</td>
<td>1,221</td>
<td>1,111</td>
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<td>1,549</td>
<td>0,795</td>
<td>1,038</td>
<td>0,764</td>
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<td>1,199</td>
<td>1,252</td>
<td>1,421</td>
<td>1,451</td>
</tr>
<tr>
<td>Lausanne, Switzerland</td>
<td>1,315</td>
<td>1,186</td>
<td>1,178</td>
<td>0,419</td>
<td>0,606</td>
<td>0,818</td>
<td>0,763</td>
<td>0,792</td>
<td>1,514</td>
<td>1,418</td>
<td>1,043</td>
</tr>
<tr>
<td>Ankara, Turkey</td>
<td>0,979</td>
<td>1,401</td>
<td>1,403</td>
<td>0,800</td>
<td>1,330</td>
<td>1,724</td>
<td>1,050</td>
<td>0,531</td>
<td>1,985</td>
<td>1,191</td>
<td>1,645</td>
</tr>
<tr>
<td>Warsaw, Poland</td>
<td>1,493</td>
<td>1,814</td>
<td>1,693</td>
<td>0,644</td>
<td>1,545</td>
<td>1,728</td>
<td>0,615</td>
<td>0,736</td>
<td>2,190</td>
<td>1,268</td>
<td>1,973</td>
</tr>
</tbody>
</table>

Table 2. Minkowski distances between detected substances and laboratories.

Stimu: Stimulants; Narco: Narcotics; Cann: Cannabinoids; Anab: Anabolic agents; Horm: Peptide hormones; Beta2: Beta-2-Agonists; Antio: Agents with antioestrogenic activity; Mask: Masking Agents / Diuretics; Gluco: Glucocorticosteroids; BetaB: Beta-Blockers; Other: Others.
Adverse analytical findings in European anti-doping laboratories

Table 3. Substances with lower Minkowski distances detected in every laboratory.

<table>
<thead>
<tr>
<th>Laboratory and country</th>
<th>1st substance (Minkowski distance)</th>
<th>2nd substance (Minkowski distance)</th>
<th>3rd substance (Minkowski distance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seibersdorf, Austria</td>
<td>Anabolics (0.099)</td>
<td>Masking/Diuretics (0.503)</td>
<td>Antioestrogenics (0.533)</td>
</tr>
<tr>
<td>Ghent, Belgium</td>
<td>Cannabinoids (0.493)</td>
<td>Stimulants (0.500)</td>
<td>Narcotics (0.356)</td>
</tr>
<tr>
<td>Prague, Czech Republic</td>
<td>Antioestrogenics (0.436)</td>
<td>Anabolics (0.484)</td>
<td>Masking/Diuretics (0.649)</td>
</tr>
<tr>
<td>Helsinki, Finland</td>
<td>Beta-2-Agonists (0.662)</td>
<td>Hormones (0.807)</td>
<td>Anabolics (1.000)</td>
</tr>
<tr>
<td>Paris, France</td>
<td>Glucocorticosteroids (0.343)</td>
<td>Cannabinoids (0.579)</td>
<td>Beta-2-Agonists (0.923)</td>
</tr>
<tr>
<td>Cologne, Germany</td>
<td>Anabolics (0.170)</td>
<td>Masking/Diuretics (0.308)</td>
<td>Antioestrogenics (0.656)</td>
</tr>
<tr>
<td>Kreischa, Germany</td>
<td>Anabolics (0.610)</td>
<td>Beta-2-Agonists (0.643)</td>
<td>Hormones (0.765)</td>
</tr>
<tr>
<td>Cambridge, United Kingdom</td>
<td>Narcotics (0.678)</td>
<td>Others (0.727)</td>
<td>Stimulants (0.761)</td>
</tr>
<tr>
<td>London, United Kingdom</td>
<td>Stimulants (0.395)</td>
<td>Narcotics (0.823)</td>
<td></td>
</tr>
<tr>
<td>Athens, Greece</td>
<td>Masking/Diuretics (0.252)</td>
<td>Anabolics (0.517)</td>
<td>Cannabinoids (0.725)</td>
</tr>
<tr>
<td>Rome, Italy</td>
<td>Hormones (0.488)</td>
<td>Anabolics (0.653)</td>
<td>Narcotics (0.755)</td>
</tr>
<tr>
<td>Oslo, Norway</td>
<td>Anabolics (0.453)</td>
<td>Beta-2-Agonists (0.693)</td>
<td>Masking/Diuretics (0.806)</td>
</tr>
<tr>
<td>Lisbon, Portugal</td>
<td>Beta-Blockers (0.359)</td>
<td>Masking/Diuretics (0.582)</td>
<td>Cannabinoids (0.764)</td>
</tr>
<tr>
<td>Moscow, Russia</td>
<td>Masking/Diuretics (0.624)</td>
<td>Anabolics (0.691)</td>
<td>Antioestrogens (0.876)</td>
</tr>
<tr>
<td>Barcelona, Spain</td>
<td>Anabolics (0.495)</td>
<td>Hormones (0.541)</td>
<td>Antioestrogens (0.757)</td>
</tr>
<tr>
<td>Madrid, Spain</td>
<td>Beta-2-Agonists (0.176)</td>
<td>Hormones (0.551)</td>
<td>Others (0.829)</td>
</tr>
<tr>
<td>Stockholm, Sweden</td>
<td>Beta-2-Agonists (0.764)</td>
<td>Anabolics (0.795)</td>
<td></td>
</tr>
<tr>
<td>Lausanne, Switzerland</td>
<td>Anabolics (0.419)</td>
<td>Hormones (0.606)</td>
<td>Antioestrogens (0.763)</td>
</tr>
<tr>
<td>Ankara, Turkey</td>
<td>Masking/Diuretics (0.531)</td>
<td>Anabolics (0.800)</td>
<td>Stimulants (0.979)</td>
</tr>
<tr>
<td>Warsaw, Poland</td>
<td>Antioestrogenics (0.615)</td>
<td>Anabolics (0.644)</td>
<td>Masking/Diuretics (0.736)</td>
</tr>
</tbody>
</table>


From the athletes in the top 10 positions of the ranking, 66 males (82.5%) and 52 females (77.6%) come from the mentioned countries and we could assume that they have been tested in laboratories highly associated to anabolic agents.

Table 6 shows the 30 first positions in the Top List 2009 Outdoor Senior Men in Athletics for Shot Put, Discus, Hammer and Javelin Throw\textsuperscript{47}. If we exclude non-European countries and consider the same laboratories mentioned above, the controls of marked countries in
Table 6 should have been carried out in these laboratories. This is the situation for 13 Shot Put athletes (81.2% of 16 Europeans), 12 Discus throwers (70.5% of 17), 20 Hammer throwers (76.9% of 26) and 15 Javelin throwers (68.1% of 22).

Of course, it is not our intention at all to say that these results are due to doping!

What we want to emphasize is that the association observed between anabolic agents and the laboratories of the Eastern European zone is related to the results that athletes from this area obtained in sports where strength is important.

Hormones

Erythropoietin (EPO) is used in endurance Sports to increase the availability of oxygen. The first suspicion about the use of EPO in sport was in the late 1980s when several cyclists died just after the appearance of this substance48.

EPO has led to several international scandals such as the withdrawal of six Chinese female athletes in Sydney 2000; the “Operation Puerto” in Spain in 2006, with at least 50 professional cyclists involved (23 were disqualified)49 or the operation of the Italian Police in Mantua, in April 2005, with more than 50 sportsmen, coaches and physicians involved.

These data show that Cycling is one of the Sports in which EPO is used more.

If we observe the world ranking of the Union Cycliste Internationale (UCI) on 22 March 201050 (Table 7), 33 of the 40 top positions (82.5%) correspond to European cyclists; 10 of them are Italian and 6 are Spanish.

The laboratories with a higher correlation (Minkowski distance) with these substances were Rome (0.488), Barcelona (0.541) and Madrid (0.551).

Although the group “Hormones” is heterogeneous, EPO and similar substances are the most common. So that, it appears to exist again a connection between the use of a substance and the laboratories of a geographical area.

Beta-2-Agonists

The prevalence of asthma and the consumption of bronchodilators in athletes have been widely studied51-59. It is known that this prevalence is higher in sportsmen than in general population51,53,57 and it is higher in endurance sports51,55. Even prevalence ranges have been reported in summer (3.7-22.8%) and winter sports (2.8-54.8%)51.
Adverse analytical findings in European anti-doping laboratories

The prevalence of asthma in Cycling is between 30 and 45% and the requests for Therapeutic Use Exemption (TUE) show a higher use of Beta-2-Agonists in Cycling and swimming. Between 2003 and 2008 the International Olympic Committee received 3174 TUE applications, 868 of which (27.3%) were for β2-agonists and 690 (79.5%) were approved.

The laboratory more closely associated to this substance was Madrid (0,176) with 356 AAF. Paris, Gante and Roma had 436, 218 and 178 AAF, but with lower Minkowski distances.

Agents with antiestrogenic activity

These agents are used to stimulate the secretion of gonadotropins and testosterone in males and to counteract some side effects such as gynecomastia or the suppression of endogenous testosterone.

The laboratories related to these substances were Prague (0,436), Seibersdorf (0,533) and Warsaw (0,615), but there were only 68 detections.

Masking/diuretics

The laboratories more closely associated to these substances Athens (0,252), Cologne (0,308) and Seibersdorf (0,503). They are used to hide or mask other drugs.

Glucocorticosteroids

Glucocorticosteroids are widely used in sport to treat soft tissues injuries, asthma or other allergic processes and systemic diseases, but it is not excluded to be used to improve performance in combination with other substances.

Table 5. European senior weightlifting championships ranking, 2009.

<table>
<thead>
<tr>
<th>Position</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>56 Kg</td>
<td>62 Kg</td>
</tr>
<tr>
<td>1</td>
<td>BEL</td>
<td>TUR</td>
</tr>
<tr>
<td>2</td>
<td>ITA</td>
<td>AZE</td>
</tr>
<tr>
<td>3</td>
<td>MDA</td>
<td>CYP</td>
</tr>
<tr>
<td>4</td>
<td>TUR</td>
<td>TUR</td>
</tr>
<tr>
<td>5</td>
<td>MDA</td>
<td>MDA</td>
</tr>
<tr>
<td>6</td>
<td>BUL</td>
<td>BUL</td>
</tr>
<tr>
<td>7</td>
<td>TUR</td>
<td>POL</td>
</tr>
<tr>
<td>8</td>
<td>ROM</td>
<td>ESP</td>
</tr>
<tr>
<td>9</td>
<td>ROM</td>
<td>FIN</td>
</tr>
<tr>
<td>10</td>
<td>FRA</td>
<td>CZE</td>
</tr>
</tbody>
</table>

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Glucocorticosteroids

Glucocorticosteroids are widely used in sport to treat soft tissues injuries, asthma or other allergic processes and systemic diseases, but it is not excluded to be used to improve performance in combination with other substances.
The declared use in UCI in 2005 was higher than 35% and this forced to revise the TUE applications for corticosteroids by its high consumption. Glucocorticosteroids are also widely used in swimmers, perhaps because of the high prevalence of bronchial hyperreactivity. The laboratory with a higher correlation with these substances was Paris (0.343) with 745 AAF. This correlation may be due to this laboratory has reported all tests with these substances, even those with a very low level. Nevertheless, we can not rule out that this finding may be related to other situations such as its administration by local infiltration or the wide use of inhaled corticosteroids by cyclists (a sport of great tradition in France).

**Beta-Blockers**

These substances are prohibited only in some Sports which require precision or driving. They are used to decrease heart rate and blood pressure, to decrease anxiety and, mainly, to decrease the muscle tremor, which improves performance in precision sports.

The laboratory more closely associated to these substances was Lisbon (0.359). We can not explain this association according to the results of Portugal in archery, modern pentathlon, motor-sports or any other precision sport.

**Others**

The heterogeneity of the Group and the few AAF do not allow any analysis.

**Study limitations**

This study has several limitations because incomplete information is available about sports analyzed by each laboratory. It is possible that...
Adverse analytical findings in European anti-doping laboratories

one laboratory can analyze samples from another geographic area. In addition, there are groups with different substances and different effects for doping.

In addition, adverse analytical findings are not separated from the true positive cases in the information provided by WADA.

On the other hand, the existence of a regional preference for the practice of some sports would change detections in the studied areas.

Some factors to be taken with caution are: the low number of findings with antihormones, the low number of findings in Cambridge and the low discrimination power of the model for the laboratories in Italy and Switzerland.

Nevertheless, this work may be a starting point to identify risk areas in relation to the consumption of certain substances.

Conclusions

- The AAF in the European laboratories show a very heterogeneous distribution.
- Detection of anabolic agents and related substances are associated to laboratories from Central and Eastern Europe (Austria, Prague, Cologne, Poland, Russia and Turkey).
- Detection of hormones is associated to Mediterranean laboratories (Rome, Barcelona and Madrid).
- Having more data, such as substances detected by sports, would allow more precise analysis of doping.

Competing interests

Authors do not have any competing interests.

References