Anti-doping analysis

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Sports drug testing has become a complex discipline facing numerous challenges, for example, the detection of prohibited drugs, the identification of prohibited methods, the discovery of manipulation, the assessment of analyte stability, etc. Because of the great variety of potential doping practices, doping-control laboratories utilize a broad spectrum of (bio) analytical approaches including (among others) mass spectrometry, isoelectric focusing/gel electrophoresis, and immunological methods. In this special issue, which is dedicated to modern anti-doping analysis, current state-of-the-art methodologies enabling comprehensive screening, sensitive confirmation procedures, metabolism studies, and quality assurance issues relevant to doping control are presented, and recent approaches and future perspectives are outlined.

Chromatography interfaced with mass spectrometry has been one of the most important tools in sports drug testing for decades, and the composition of this special issue of *Analytical and Bioanalytical Chemistry* further substantiates the fact that, in particular, liquid chromatography–(tandem) mass spectrometry (LC–MS(–MS)) with high-resolution, high-accuracy mass analyzers has gained considerable attention and use. It has been employed in comprehensive screening methods for low- and high-molecular-mass compounds and in metabolism studies of peptidic drugs, cannabimimetic compounds, stimulants, and selective estrogen receptor

modulators (SERMs). Moreover, its use to identify polysaccharide-based therapeutics has been demonstrated, and the identification of compounds indicative of autologous blood transfusion in urine specimens (i.e., urinary metabolites of phthalate-derived plasticizers) has been shown.

Complementary to mass spectrometric approaches, alternative strategies have been evaluated, tested, and implemented in routine doping control. Among these, detection methods for erythropoiesis-stimulating agents (ESAs, e.g., erythropoietin and its mimetics) are of particular importance and commonly rely on isoelectric focusing or SDS-PAGE and immunoblotting. In addition, the misuse of human growth hormone (hGH) and its detection has been a major issue for sports drug-testing authorities, and, besides the determination of hGH isoform ratios that reveal the application of recombinant hGH, a so-called marker approach has been developed that focuses on two principal products stimulated by administration of hGH. Finally, a method referred to as surface plasmon resonance (SPR) has been demonstrated to have the potential to support anti-doping efforts concerning several different analytes and could complement future drug-testing programs.

Besides sophisticated analytical chemistry, doping controls require stringent quality control and pre-analytical conditions. These are the subject of two contributions on the stabilization of urine specimens for doping control and the relevance of certified reference material to unambiguous identification and correct quantification of prohibited compound(s).

Overall, the breadth of anti-doping science requires multi-disciplinary approaches and the consideration of numerous aspects that ensure the highest-quality analysis. Hence, continuous effort to improve analytical standards and to expand test methods is necessary, and selected facets of research dedicated to sports drug testing are highlighted in this special issue.

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