The International Olympic Committee (IOC) Consensus Statement on periodic health evaluation of elite athletes

The Olympic Games is the largest sport event in the world. In Beijing, 10 500 athletes compete selected from a large group of elite athletes in 204 countries. Sports participation on the elite level, aside from winning medals, fame and other rewards, is also important from a health perspective. There is no longer any doubt that regular physical activity reduces the risk of premature mortality in general, and of coronary heart disease, hypertension, colon cancer, obesity and diabetes mellitus in particular. The question is whether the health benefits of sports participation outweigh the risk of injury and long-term disability, especially in high-level athletes. Sarna *et al*[1] have studied the incidence of chronic disease and life expectancy of former male world-class athletes from Finland in endurance sports, power sports and team sports. The overall life expectancy was longer in the high-level athlete compared with a reference group (75.6 vs 69.9 years). The same group also showed that the rate of hospitalisation later in life was lower for endurance sports and power sports compared with the reference group.[2] This resulted from a lower rate of hospital care for heart disease, respiratory disease and cancer. However, the athletes were more likely to have been hospitalised for musculoskeletal disorders. Thus, the evidence suggests that although there is a general health benefit from sports participation, injuries represent a significant side effect.

One priority of the International Olympic Committee (IOC) is to protect the health of the athlete. During recent years, prevention of injuries and illnesses has been high on the IOC agenda. During the Athens Games, an injury surveillance system was applied for all team sports.[3] During the Beijing Games, the IOC ran, for the first time, an injury surveillance system covering all the athletes, showing a 10% incidence of injuries.[4] In Vancouver and London, the surveillance system will include disease conditions as well. The surveillance studies are prerequisites for providing evidence for health development in sports as well as for developing prevention programmes. Another method to decrease injuries and diseases in the elite athlete is to perform a preparticipation examination (PPE) or periodic health evaluation (PHE) of all elite athletes.[5] PHE in various forms have been available for many years, but a recent analysis[5] has questioned the efficacy of PHEs in detecting serious problems in the elite athlete.

In March 2009, the IOC assembled an expert group to discuss the current state of health evaluations for athletes, aiming to provide recommendations for a practical PHE for the elite athlete, as well as to outline the need for further research. The task of the group was to review the benefits as well as potential negative effects of PHE at the elite sport level. The group did not take any position as to whether PHE should be recommended as compulsory for participation in sport. That is for the relevant sports authorities to decide.

The PHE can serve many purposes. It includes a comprehensive assessment of the athlete's current health status and risk of future injury or disease and, typically, is the entry point for medical care of the athlete. The PHE also serves as a tool for continuous health monitoring in athletes. Recent advances in this field relate

to: (1) data on sudden cardiac death and other non-cardiac medical problems, and the detection of risk factors and groups; (2) a consensus conference on concussion; (3) data on eating disorders; and (4) data on risk factors for musculoskeletal injuries. This paper addresses each of these advances in more detail after a discussion on the purpose of a PHE and the evidence we have supporting the different components of the PHE.

Next Section Purposes of the medical evaluation

In a narrow sense, the main purpose of the PHE is to screen for injuries or medical conditions that may place an athlete at risk for safe participation. Athletes may be affected by conditions that do not have overt symptoms and that can only be detected by periodic health evaluations. One example is cardiovascular abnormalities, such as hypertrophic cardiomyopathy, arrythmogenic right ventricular cardiomyopathy or congenital coronary arteries anomalies. These are typically silent until a potentially fatal arrhythmia occurs but may in some cases be detected through a careful cardiovascular examination.

Screening is a strategy used in a population to detect a disease in individuals without signs or symptoms of that disease. The intention is to identify pathological conditions early, thus enabling earlier intervention and management in the hope of reducing future morbidity and mortality. Although screening may lead to an earlier diagnosis, not all screening programmes have been shown to benefit the person being screened.

To ensure that screening programmes confer the intended benefit, the World Health Organization published what have become known as the Wilson–Jungner criteria for appraising a screening programme.[6] The main criteria are that the condition being screened for is an important health problem (depending not just on how serious the condition is, but also how common it is), that there is a detectable early stage, that treatment at an early stage is of more benefit than at a later stage and that a suitable test is available to detect disease in the early stage.

From a public health perspective, there is insufficient evidence to date to mandate any specific screening tests for elite athletes apart from those recommended for the general population. This is mainly the consequence of the low risk of serious conditions in this population. An important limitation is also the lack of suitable screening tests; such tests must be reliable (repeatable, good interobserver agreement), sensitive (detects all those with increased risk), specific (detects only those with increased risk), affordable (ideally cheap, easy to perform, widely available), acceptable to the screening population and subject to quality assurance.

However, the PHE may serve other purposes than just screening athletes for future health problems. One obvious goal is to ensure that current health problems are managed appropriately and, ultimately, to determine whether an athlete is medically suitable to engage in a particular sport or event. Even elite athletes with easy access to medical care do not always seek medical attention for injuries or disease, despite having significant symptoms.

Some silent conditions are common and, although not severe from a health perspective, may influence sports performance. An example of this is mild iron deficiency, which is common in female athletes. Periodic health evaluations and ongoing monitoring represent an opportunity to diagnose and manage such conditions. They also provide an opportunity to identify conditions that are barriers to performance. An example is astigmatism, which can be detected on a simple test of visual acuity. Another important function of periodic health evaluations is that they allow the athlete an opportunity to establish a relationship with the health personnel who will be involved in providing continuing care.

Finally, the PHE also represents an opportunity to look for characteristics which may put the elite athlete at risk for future injury or disease. However, as mentioned above, there is limited direct evidence to suggest that it is possible to predict future outcomes based on the PHE. Nevertheless, there is evidence in some areas, such as injury risk factor assessment,[7] that holds future promise and warrants investigation related to the PHE. Depending on the sport and the age, ethnic origin and gender of the athlete, it may be prudent to include an assessment of specific risk factors in the PHE.

Previous SectionNext Section

General requirements of a PHE

It is important to address and balance the ethical and legal aspects of the PHE in order to help protect the rights and responsibilities of athletes, physicians, sporting organisations and other persons concerned. In the context of designing and implementing a PHE, the following considerations need to be taken into account:

- PHE should be based on sound scientific and medical criteria.
- PHE should be performed in the primary interest of the athlete, that is, assessing their health in relation to their practice of a given sport.
- PHE should be performed under the responsibility of a physician trained in sports medicine, preferably by the physician responsible for providing ongoing medical care for the athlete—for example, the team physician.
- The decision concerning the nature and scope of the PHE should take into account individual factors, such as the geographical region, the sport discipline, the level of competition, age and gender of the athlete.
- The setting of the evaluation should be chosen to optimise the accuracy of the examination and respect the privacy of the athlete. The PHE should preferably be carried out in the physician’s office, which assures privacy, access to prior medical records and an appropriate patient–physician relationship.
- A physician can only perform a PHE with the free and informed consent of the athlete and, if applicable, their legal guardian.

If PHE evidences that an athlete is at serious medical risk, the physician must strongly discourage the athlete from continuing training or competing until the necessary medical measures have been taken.

Based on such advice, it is the responsibility of the athlete to decide whether to continue training or competing.

If a physician is requested to issue a medical certificate, they must have explained in advance to the athlete the reason for the PHE and its outcome, as well as the nature of information provided to the third parties. In principle, the medical certificate may only indicate the athlete's fitness or unfitness to participate in training or competition and should minimise disclosure of confidential medical information.

In many settings, the PHE is used to offer medical clearance to participate in sport and is seen as a one-time certification for future involvement in elite sport. However, the evaluation of the athlete's health should ideally be seen as a dynamic, ongoing process.

While many aspects of the PHE will be common to all elite athletes, it should be tailored to be gender, age, race, culture and sport specific when appropriate. If any injury or medical condition is identified, it should be managed in a manner consistent with the existing standards of medical care. If warranted, this may involve referral to the appropriate specialists for further evaluation and management. It should be noted that the PHE is also the time that medications or nutritional products in use or prescribed should be reviewed to determine if a Therapeutic Use Exemption (TUE) application to the World Anti Doping Association (WADA) is needed.

The timing of the PHE should ideally allow for sufficient time for management of any injuries or medical problems well before major competitions. For example, it is preferable to conduct a PHE during the off-season so that rehabilitation or other treatment can restore the athlete to optimal health before facing maximal physical stress.

As the PHE is the only contact that many elite athletes will have with medical personnel, it should be seen as an opportunity for education regarding other health risks and health-related behaviour.

The following document is laid out in sections that correspond to the various areas of evaluation appropriate to the elite athlete.

Previous SectionNext Section

1. Cardiology

1.1 Introduction

The scope of the cardiovascular PHE is to detect potentially lethal cardiovascular disease in elite athletes and start appropriate management to reduce the risk for sudden cardiac death and/or disease progression in a timely fashion.

1.2 Evidence base

Cardiovascular (CV) risk of competitive sport participation

Regular participation in training and athletic competition is associated with an increased risk for sudden cardiac death (SCD), with an average relative risk for athletes of 2.8 times compared with their non-athletic counterpart.[8] It is worth noting, however, that sport is not per se the cause for greater incidence of SCD. It is the combination of intensive physical exercise in athletes with underlying cardiovascular disease, which can trigger ominous arrhythmias leading to cardiac arrest. The relative risk of sport participation is different according to the underlying disease, and it is greatest in case of cardiomyopathies (such as hypertrophic cardiomyopathy or arrhythmogenic right ventricular cardiomyopathy) or congenital coronary arteries anomalies (Corrado *et al* 2003).

Rationale for CV evaluation in elite competitive athletes

The vast majority of the athletes dying suddenly do not experience premonitory symptoms;[9] therefore, the PHE represents the only strategy capable of identifying athletes with silent cardiac disease, and allowing appropriate management to reduce the risk of SCD and disease progression. Identifying asymptomatic athletes with underlying cardiovascular disease through the PHE is important because SCD could be prevented by lifestyle modification, including (when necessary) restriction from competitive sports activity, but also prophylactic treatment by drugs, implantable cardioverter defibrillator (ICD) or other therapeutic options. Athletes carrying an increased cardiac risk may have a favourable long-term outcome thanks to timely identification and appropriate clinical management.[10]

Rationale for including the 12-lead ECG in the PHE

Recent scientific evidence supports the role of ECG in reducing mortality in screened athletes.[11] This concept is based on the recognition that ECG is abnormal in most individuals with hypertrophic cardiomyopathy (up to 90%) and arrhythmogenic right ventricular cardiomyopathy (up to 80%). The ECG can also identify athletes with WPW syndrome and ion channel diseases, such as Lènegre conduction disease, long or short QT syndromes and Brugada syndrome.[12] [13] However, there has been criticism voiced related to available data on the use of ECG in the elite athlete based on lack of an unscreened athletic control group. A comparison of athletes screened with ECG versus non-screened athletes will require two matched large athlete populations (several thousand athletes, in consideration of the low incidence of cardiomyopathies) undergoing long-term follow-up (at least two decades, due to the young age of athletes at initial evaluation).

It has been demonstrated that adding a 12-lead ECG examination to history and physical examination results in a substantial increase in the ability to identify potentially lethal heart disorders,[12] [13] and this strategy has been endorsed in "The Lausanne Recommendations"[14] and the European Society of Cardiology recommendations.[15] However, it is not currently recommended by the American Heart Association.[16] [17]

1.3 Proposal for PHE

The following questions regarding cardiovascular abnormalities should be included:

Family history:

Family history of one or more relatives with disability or death of heart disease (sudden/unexpected) before age 50.

Family history of cardiomyopathy, coronary artery disease, Marfan syndrome, long QT syndrome, severe arrhythmias, or other disabling cardiovascular disease.

Personal history:

syncope or near-syncope;

exertional chest pain or discomfort;

shortness of breath or fatigue out of proportion to the degree of physical effort;

palpitations or irregular heartbeat.

Physical examination should be performed according to the best clinical care and should investigate the presence of:

musculoskeletal and ocular features suggestive of Marfan syndrome;

diminished and delayed femoral artery pulses;

mid- or end-systolic clicks;

abnormal second heart sound (single or widely split and fixed with respiration);

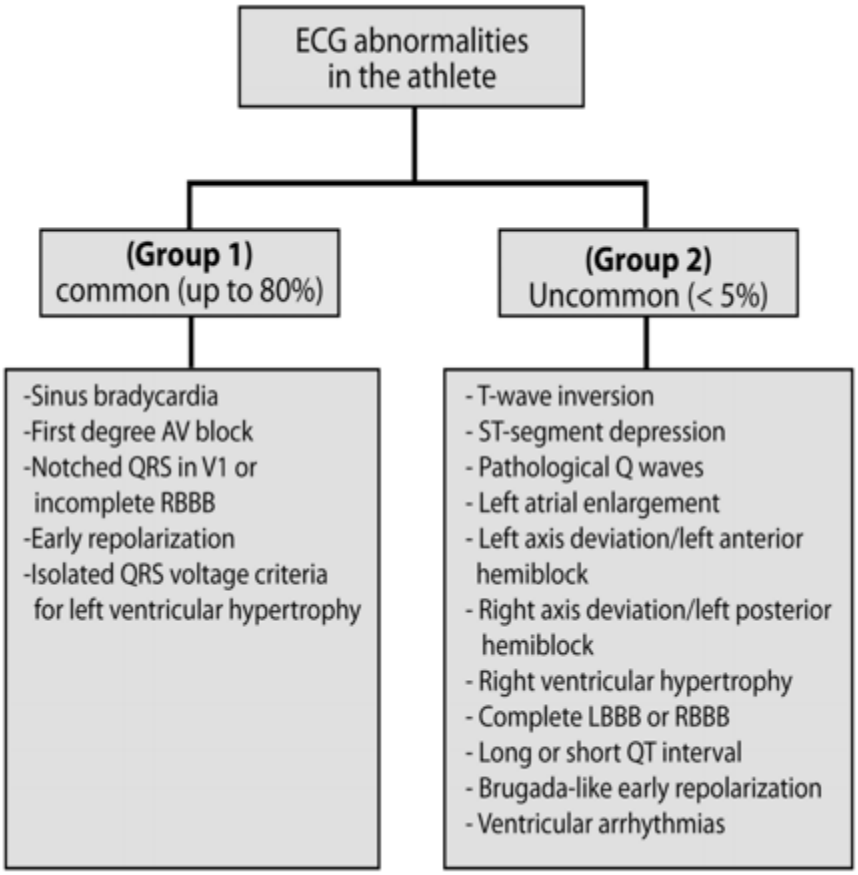
heart murmurs (systolic grade >2/6 and any diastolic);

irregular heart rhythm;

brachial, bilateral blood pressure >140/90 mm Hg on more than one reading.

Twelve-lead ECG

The 12-lead ECG should be recorded on a non-training day, during rest, according to best clinical practice. Interpretation of the ECG abnormalities can be categorised according to the criteria defined by Corrado *et al*[18] into two groups: (1) the most common in trained athletes (sinus bradycardia, first degree AV block, notched QRS in V1 or incomplete right bundle branch block, isolated QRS voltage criteria for LV hypertrophy) consistent with athlete's age, ethnical origin and level of athletic conditioning, and that do not require additional testing; (2) all other less common ECG abnormalities further evaluated to exclude cardiovascular disease (fig 1).



View larger version:

In a new window

Download as PowerPoint Slide

Figure 1

Twelve-lead ECG abnormalities.

Further investigations

At present, there is no agreement regarding the need for routine use of echocardiography in the PHE. Neither is there a role for routine use of other imaging or invasive testing. However, in the presence of abnormal findings at history, physical examination or 12-lead ECG, additional testing should be performed in order to confirm (or exclude) cardiovascular disease. In most instances, echocardiography is the first-line test, but other imaging modalities (such as cardiac magnetic resonance) or invasive testing, when necessary, may be pursued. In adult athletes (>35 years) exercise ECG testing in the context of PHE is efficient to detect otherwise unsuspected cardiac abnormalities[19] and is currently recommended for elite athletes with increased cardiovascular risk profile.[20]

1.4 Management of athletes with CV abnormalities

The IOC PHE Consensus Group recommends that any athlete identified with a CV abnormality should be managed according to the current, widely accepted clinical recommendations, that is, Bethesda Conference #36 and ESC recommendations.[21 22] The group acknowledges that identification of cardiac disease in an athlete represents a challenging question regarding the ethical, medical and legal consequence with particular regard to the need for disqualification from competition. However, there is scientific evidence that preventing athletes with specific cardiovascular abnormality from regular training and competition is an efficient strategy for preventing SCD.[10 23] Unnecessary exclusion from participation of competitive athletes with non-lethal diseases is a problem. Therefore, there is a need for a common agreement of sports eligibility guidelines and management of competitive athletes with cardiovascular diseases in the future.[24] The main goal should be to reduce the number of unnecessary disqualifications and to adapt (rather than restrict) sports activity in relation to the specific cardiovascular risk.

Finally, we recognise that young competitive athletes (<18 years) require specific expertise in the evaluation, interpretation of findings and management.

1.5 Educational programmes

The sport organisations together with scientific sport societies should encourage and support educational activities intended to enhance the knowledge and skill of physicians involved in the cardiology part of the PHE process.

1.6 Research

Although there are issues of debate regarding wide-scale mandatory use of the ECG for athlete screening,[16 24] there is sufficient evidence to justify a staged implementation with evaluation to assess the properties of the test (sensitivity, specificity, predictive value) in a variety of sporting populations. Staged implementation would provide a natural control group to measure differences in outcome between ECG screened and unscreened groups. Finally, the mortality effects of a screening programme documented in Italy need to be replicated in other ethnic populations where the underlying disease conditions may differ from those seen in Italy.

The sport organisations and scientific sport societies should encourage research that could expand our current knowledge and database regarding the mechanisms and strategies to prevent SCD in competitive athletes.

***Br J Sports Med* 2009;43:631-643 doi:10.1136/bjsm.2009.064394**

References

1. Rompe JD, Nafe B, Furia JP, *et al*. Eccentric loading, shock-wave treatment, or a wait-and-see policy for tendinopathy of the main body of tendo achillis: a randomized controlled trial. *Am J Sports Med* 2007;**35**:374-383.

2. Ljungqvist A, Schwellnus M, Bachl N, *et al.* International Olympic Committee consensus statement. Molecular basis of connective tissue and muscle injuries in sport. *Clin Sports Med* 2008;**27**:231-239.
3. Mei-Dan O, Mann G, Maffulli N. Platelet-rich plasma: any substance into it? *Br J Sports Med* 2010;**44**:618-619.
4. Berghoff WJ, Pietrzak WS, Rhodes RD. Platelet-rich plasma application during closure following total knee arthroplasty. *Orthopedics* 2006;**29**:590-598.
5. Everts PAM, Devilee RJJ, Brown-Mahoney Ch, *et al.* Platelet gel and fibrin sealant reduce allogenic blood transfusions and in total knee arthroplasty. *Acta Anaesthesiol Scand* 2006;**50**:539-590.
6. Anitua E. Plasma Rich in Growth factors: preliminary results of use in the preparation of sites for implants. *Int J Oral Maxillofacial Implants* 1999;**14**:529-535.
7. Marx RE, Carlson ER, Eichstaedt RM, *et al.* Platelet rich plasma: Growth factor enhancement for bone grafts. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1998;**85**:638-646.
8. Everts PAM, Devilee RJJ, Brown Mahoney C, *et al.* Exogenous application of platelet-leukocyte gel during open subacromial decompression contributes to improved patient outcome. A prospective randomized double-blinded study. *Eur Surg Res* 2008;**40**:203-210.
9. Everts PA, Jakimowicz M, van Beek, *et al.* Reviewing the structural features of autologous platelet-leukocyte gel and suggestions for use in surgery. *Europ Surg Res* 2007;**39**:199-207.
10. Sánchez M, Anitua E, Azofra J, *et al.* Intraarticular injection of an autologous preparation rich in growth factors for the treatment of knee OA: a retrospective cohort study. *Clin Exp Rheumatol* 2008;**26**:910-913.
11. Ishida K, Kuroda R, Miwa M, *et al.* The regenerative effects of platelet-rich plasma on meniscal cells in vitro and its in vivo application with biodegradable gelatin hydrogel. *Tissue Eng* 2007;**13:**1103-1112.
12. Radice F, Yánez R, Gutiérrez V, *et al.* Comparison of magnetic resonance imaging findings in anterior cruciate ligament grafts with and without autologous platelet-derived growth factors. *Arthroscopy* 2010;**26**:50-57.
13. Kawasumi M, Kitoh H, Siwicka KA, *et al.* The effect of the platelet concentration in platelet-rich plasma gel on the regeneration of bone. *J Bone Joint Surg* 2008;**90**:966-972.
14. Wright-Carpenter T, Klein P, Schäferhoff P, *et al.* Treatment of muscle injuries by local administration of autologous conditioned serum: a pilot study on sportsmen with muscle strains. *Int J Sports Med* 2004;**25:**588-593.
15. Magra M, Maffulli N. Nonsteroidal antiinflammatory drugs in tendinopathy: friend or foe. *Clin J Sport Med* 2006;**16**:1-3.
16. Sanchez M, Azofra J, Anitua E, *et al.* Plasma rich in growth factors to treat an articular cartilage avulsion: A case report. *Med Sci Sports Exer* 2003;**35**:1648-1652.
17. Bachl N, Derman W, Engebretsen L, *et al.* Therapeutic use of growth factors in the musculoskeletal system in sports-related injuries. *J Sports Med Phys Fitness* 2009;**49**:346-357.
18. Gibble J, Ness P. Fibrin glue: the perfect operative sealant? *Transfusion* 1990;**30**:741-47.
19. Ferrari M, Zia S, Valbonesi M, *et al.* A new technique for hemodilution, preparation of autologous platelet-rich plasma and intraoperative blood salvage in cardiac surgery. *Int J Artif Org* 1987;**10**:47-50.
20. Mishra A, Pavelko T. Treatment of chronic elbow tendinosis with buffered platelet-rich plasma. Am J Sports Med 2006;**34**:1774-1778.
21. Harrison P, Cramer EM. Platelet alpha-granules. *Blood Reviews* 1993;**7**:52-62.
22. Anitua E, Andía I, Ardanza B, *et al.* Autologous platelets as a source of proteins for healing and tissue regeneration. *Thromb Haem* 2004;**91**:4-15.
23. Italiano JE Jr, Battinelli EM. Selective sorting of alpha-granule proteins. *J Thromb Haemost* 2009;**7(Suppl 1)**:173-176.

24. Marx RE. Platelet-rich plasma (PRP): What is PRP and what is not PRP? *Implant dentistry* 2001;**10**:225-228.
25. Andia I, Sanchez M, Maffulli N. Tendon healing and platelet-rich plasma therapies. Expert Opin Biol Ther 2010;10:1415-1426.
26. Marx RE. Platelet-rich plasma: evidence to support its use. *J Oral Maxillofac Surg* 2004;**62**:489-496.
27. De Mos M, van der Windt AE, Jahr H, *et al.* Can platelet-rich plasma enhance tendon repair? A cell culture study. *Am J Sports Med* 2008;**36**:1171-1178.
28. Fufa D, Shealy B, Jacobson M, *et al.* Activation of PRP using soluble type I collagen. *J Oral Maxillofac Surg* 2008;**66**:684-690.
29. Foster TE, Puskas BL, Mandelbaum BR, *et al.* Platelet rich plasma. *Am J Sport Med* 2009;**37**: 2259-2272.
30. Schnabel LV, Mohammed HO, Miller BJ, *et al.* Platelet rich plasma (PRP) enhances anabolic gene expression patterns in flexor digitorum superficialis tendons. *J Orthop Res* 2007;**25**:230-240.
31. Zhang J, Wang JH. Platelet-Rich plasma releasate promotes differentiation of tendon stem-cells into active tenocytes. *Am J Sports Med* 2010: PMID 20802092 Epub ahead of print
32. Kajikawa Y, Morihara T, Sakamoto H, *et al.* Platelet-rich plasma enhances the initial mobilization of circulation-derived cells for tendon healing. *J Cellular Physiology* 2008; **215**:837-845.
33. Aspenberg P, Virchenko O. Platelet concentrate injection improves Achilles tendon repair in rats. *Acta Orthopedica Scand* 2004;**75**:93-99.
34. Eliasson P, Fahlgren A, Pasternak B, *et al.* Unloaded rat Achilles tendons continue to grow, but lose viscoelasticity. *J Appl Physiol* 2007;**103**:459-463.
35. Saito M, Takahashi KA, Arai Y, *et al.* Intraarticular administration of platelet-rich plasma with biodegradable gelatin hydrogel microspheres prevents osteoarthritis progression in the rabbit knee. *Clin Exp Rheumatol* 2009;27:201-207.
36. Wu W, Chen F, Liu Y, *et al.* Autologous injectable tissue-engineered cartilage by using platelet-rich plasma: experimental study in a rabbit model. *J Oral Maxillofac Surg* 2007;**65**:1951-1957.
37. O'Keefe RJ, Crabb ID, Puzas JE, *et al.* Effects of transforming growth factor-beta 1 and fibroblast growth factor on DNA synthesis in growth plate chondrocytes are enhanced by insulin-like growth factor-I. *J Orthop Res* 1994;**12**:299-310.
38. Lee J, Harwood FL, Akeson WH, *et al.* Growth factor expression in healing rabbit medial collateral and anterior cruciate ligaments. *Iowa Orthop J* 1998;**18**:19-25.
39. Tsay RC, Vo J, Burke A, *et al.* Differential growth factor retention by platelet rich plasma composites. *J Oral Maxillofac Surg* 2005;**63**:521-528.
40. Lehrer RI, *et al.* Neutrophils and host defense. *Ann Intern Med* 1988;**109**:127-142.
41. Yeaman MR. The role of platelets in antimicrobial host defense. *Clin Infect Dis* 1997;**25**:951-968.
42. Hammer JH, *et al.* Bacterial antigen-induced release of white cell- and platelet-derived bioactive substances in vitro. *Int J Gastrointest Cancer* 2002;**31**:165-179.
43. Zander DM, Klinger M. The blood platelets contribution to innate host defense - what they have learned from their big brothers. *Biotechnol J* 2009;**4**:914-926.
44. Stallmann HP, *et al.* Antimicrobial peptides: review of their application in musculoskeletal infections. *Injury* 2006;**37(Suppl 2)**:S34-S40.
45. Everts PAM, Knape JTA, Weibrich G, *et al.* Platelet rich plasma and platelet gel. *J Extra Corp Techn* 2006;**38**:174-187.
46. Trowbridge CC, *et al.* Use of platelet gel and its effects on infection in cardiac surgery. *J Extra Corpor Technol* 2005;**37**:381-386.
47. Moojen DJ, *et al.* Antimicrobial activity of platelet-leukocyte gel against Staphylococcus aureus. *J Orthop Res* 2008;**26**:404-410.
48. Bielecki TM, *et al.* Antibacterial effect of autologous platelet gel enriched with growth factors and other active substances: an in vitro study. *J Bone Joint Surg* 2007;**89**:417-420.
49. Ekstrand J, Hägglund M, Waldén M. Injury incidence and injury patterns in professional football - the UEFA injury study. *Br J Sports Med* 2010; May 29 [Epub ahead of print]. 25-26

50. Orchard J, Seward H. Epidemiology of injuries in the Australian Football League seasons 1997-2000. *Br J Sports Med* 2002;**36**:39-44.
51. Sherry MA, Best TM. A comparison of two rehabilitation programs in the treatment of acute hamstring strains. *J Orthop Sports Phys Ther* 2004;**34**:116-125.
52. Orchard J, Best TM, Verrall GM. Return to play following muscle strains. *Clin J Sports Med* 2005;**39**:363-368.
53. Malliaropoulos N, Ntessalen M, Papacostas E, *et al.*. Reinjury after acute lateral ankle sprains in elite track and field athletes. *Am J Sports Med* 2009;**37**:1755-1761.
54. Malliaropoulos N, Papacostas E, , Papalada A, *et al.* Posterior thigh muscle injuries in elite track and field athletes. *Am J Sports Med* 2010;**38**:1813-1819.
55. Orchard J, Best TM, Müller-Wohlfart HW, *et al.* The early management of muscle strains in the elite athlete: best practice in a world with a limited evidence basis. *Br J Sports Med* 2008;**42**:158-159.
56. McCrory P, Franklyn-Miller A, Etherington J. Sports and exercise medicine - new specialists or snake oil salesmen? *Br Journal Sport Med* 2010 Jun 27 [Epub ahead of print].
57. Menetrey J, Kasemkijwattana C, Day CS. Growth factors improve muscle healing in vivo. *J Bone Joint Surgery* 2000;**82**:131-137.
58. Borselli C, Storrie H, Benesch-Lee F, *et al.*. Functional muscle regeneration with combined delivery of angiogenesis and myogenic factors. *Proc Natl Acad Sci* 2010;**107**:3287-3292.
59. Hammond J, Hinton RY, Curl LA, *et al.* Use of autologous platelet-rich plasma to treat muscle strain injuries. *Am Journal Sports Med* 2009;**37**:1135-1142.
60. Loo W, Lee D, Soon M. Plasma rich in growth factors to treat adductor longus tear. *Ann Acad Med Singapore* 2009;**38**:733-734.
61. Hamilton B, Knez W, Eirale C, *et al.* Platelet enriched plasma for acute muscle injury. *Acta Orthop Belg* 2010;**76**,443-448.
62. Maffulli N, Khan KM, Puddu G. Overuse tendon conditions: time to change a confusing terminology. *Arthroscopy* 1998;**14**:840- 843.
63. Maffulli N, Longo UG. Conservative management for tendinopathy: is there enough scientific evidence? *Rheumatology* 2008;**47**:390-391.
64. Rees JD, Maffulli N, Cook J. Management of tendinopathy. Am Journal Sports Med 2009;37:1855-1867.
65. Kovacevic D, Rodeo SA. Biological augmentation of rotator cuff tendon repair. *Clin Orthop Rel Research* 2008; **466**:622-633.
66. Gawedal M, Tarczynska W, Krzyzanowskia C. Treatment of achilies tendinopathy with platelet-rich plasma. *Int J Sports Med* 2010;**31**:577-583.
67. Sánchez M, Anitua E, Azofra J, *et al.* Comparison of surgically repaired Achilles tendon tears using platelet-rich fibrin matrices. *Am J Sports Med* 2007;35:245-251.
68. Filardo G, Kon K, Buda R. Platelet-rich plasma intra-articular knee injections for the treatment of degenerative cartilage lesions and osteoarthritis. *Knee Surg Sports Traumatol Arthros* 2010; epub ahead of print.
69. Kon E, Filardo G, Delcogliano M, *et al.* Platelet-rich plasma: new clinical application: a pilot study for treatment of jumper's knee. *Injury* 2009;**40**:598-603.
70. Randelli PS, Arrigoni P, Cabitza P*, et al.* Autologous platelet rich plasma for arthroscopic rotator cuff repair: A pilot study. *Disabil Rehabil* 2008;**30**:1584-1589.
71. Peerbooms JC, Sluimer J, Bruijn DJ, *et al.* Positive effect of an autologous platelet concentrate in lateral epicondylitis in a double-blind randomized controlled trial: platelet-rich plasma versus corticosteroid injection with a 1-year follow-up. *Am J Sports Med* 2010;**38**:255-262.
72. De Vos RJ, Weir A, van Schie HT, *et al.* Platelet-rich plasma injection for chronic Achilles tendinopathy: a randomized controlled trial. *JAMA* 2010;**303**:144-149.
73. Randelli P, Arrigoni P, Ragone V, *et al.*. Platelet Rich Plasma (PRP) in arthroscopic rotator cuff repair. A prospective RCT study, 2 years follow-up. JSES 2010 [In press] 26-26

74. Castricini R, Longo UG, De Benedetto M, *et al*. Platelet-rich fibrin matrix augmentation for arthroscopic rotator cuff repair: a randomised controlled trial. *Am J Sports Med* 2010 [in press].
75. De Vos RJ, van Veldhoven PL, Moen MH, *et al*. Autologous growth factor injections in chronic tendinopathy: a systematic review. *Br Med Bull* 2010;**95**:63-77.
76. Milano G, Sanna Passino E, Deriu L, *et al*. The effect of platelet rich plasma combined with microfractures on the treatment of chondral defects: an experimental study in a sheep model. *Osteoarthritis Cartilage* 2010;**18**:971-980.
77. Kon E, Buda R, Filardo G, *et al*. Platelet-rich plasma: intra-articular knee injections produced favorable results on degenerative cartilage lesions. Knee *Surg Sports Traumatol Arthrosc* 2010;**18**:472-479.
78. Philippon MJ, Schroder e Souza B, Briggs KK. Labrum: resection, repair and reconstruction sports medicine and arthroscopy review. *Sports Med Arthrosc* 2010;**18**:76-82.
79. Philippon MJ, Briggs KK, Hay CJ, *et al*. Arthroscopic labral reconstruction in the hip using iliotibial band autograft: technique and early outcomes. Arthroscopy 2010;26:750-756.
80. Arnoczky SP, Anderson L, Fanelli G, *et al*. The role of platelet-rich plasma in connective tissue repair. *Orthopedics Today* 2009;**26**:29.
81. Silva A, Sampaio R. Anatomic ACL reconstruction: does the platelet-rich plasma accelerate tendon healing? *Knee Surg Sports Traumatol Arthrosc* 2009;17:676-682.
82. Orrego M, Larrain C, Rosales J, *et al*. Effects of platelet concentrate and bone plug on the healing of hamstring tendons in bone tunnel. *Arthroscopy* 2008;**24**:1373-1380.
83. Anitua E, Orive G. Short implants in maxillae and mandibles: a retrospective study with 1 to 8 years of follow-up. *J Periodontol* 2010;**81**:819-826.
84. Anitua E, Orive G, Aguirre JJ, *et al*. 5-year clinical experience with BTI dental implants: risk factors for implant failure. *J Clin Periodontology* 2008;**35**:724-732.
85. Wang-Saugusa W, Cugat R, Area O, *et al*. Infiltration of plasma rich in growth factors for osteoarthritis of the knee: short-term effects on function and quality of life. *Arch Orthop Surg* 2010 (In Press).
86. Spero JA. Bovine thrombin-induced inhibitor of factor V and bleeding risk in postoperative neurosurgical patients. Report of three cases. *J Neurosurg* 1993;**78**:817-820.
87. Cmolik BL, Spero JA, Magovern GJ, *et al*. Redo cardiac surgery: late bleeding complications from topical thrombin-induced factor V deficiency. *J Thorac Cardiovasc Surg* 1993;**105**:222-227.
88. Ortel TL, Mercer MC, Thames EH, *et al*. Immunologic impact and clinical outcomes after surgical exposure to bovine thrombin. *Ann Surg* 2001;**233**:88-96.
89. Schulz KF, Altman DG, Moher D, *et al*. CONSORT 2010 statement: updated guidelines for reporting parallel group randomized trials. *Ann Intern Med* 2010;**152**:726-732.
90. WADA, The World Anti-Doping Code: The Prohibited List 2010. International Standard 2009, World Anti-Doping Agency: Montreal.
91. Banfi G, Corsi MM, Volpi P. Platelet rich plasma (PRP) could have effects on systemic circulating growth factors and cytokines release in orthopedic applications? *Br J Sports Med* 2006;**40**:816.
92. WADA The World Anti-Doping Code: The Prohibited List 2011. World Anti-Doping Agency: Montreal.