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EDITORIAL

EVOLUTION – THE DRIVING FORCE IN FOOTBALL MEDICINE

Since the last edition of Medicine Matters, UEFA has hosted its sixth medical symposium, with doctors from all across Europe coming together in Madrid to discuss past, present and future developments in football medicine. It is this desire within the football medicine community to learn, to develop, to share and, most importantly, to innovate which continues to ensure that football leads the way in areas such as injury research, education and player safety. It has been my privilege to attend four UEFA symposiums, where I have seen medical professionals who have devoted their careers to football medicine sitting alongside younger doctors and physiotherapists who are just starting out, all sharing their knowledge, experience and new ideas with a view to reducing injuries, improving performance within the limits of the law and ensuring the finest standards of care are available for players when they have the misfortune to sustain a serious injury.

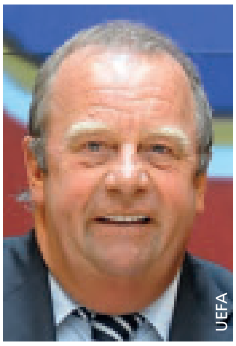
It is also my immense pleasure to witness what is now a real European football medicine community in development. UEFA's education programmes, its competitions, its doctors' forums and events such as the symposium are helping to bring together medical specialists from all corners of the continent, in an atmosphere of friendship, mutual respect and cordiality, meaning that when teams visit a new country for the first time, they will see familiar faces and can be confident that their hosts have medical staff who are trained to the same level as in any other country. This is an incredible achievement and one in which all doctors within European football should take great pride.

However, an evolving organisation never stops, it always looks to the future, and it is because of this that UEFA and its Medical Committee continue to find new ways to innovate or to further refine existing programmes. The third and final workshop of the UEFA Football Doctor Education Programme will be held in February 2015, the culmination of years of hard work by doctors from each national association in improving their skills and their knowledge of football-specific medical issues. The graduates of this programme are also passing on the skills that they have learned to their compatriots: 25 countries have already 'cascaded' the UEFA emergency treatment workshop since 2012. In addition, the 2014/15 season will see the introduction of a refined version of UEFA's minimum medical requirements, which stipulate the level of medical service to be provided at UEFA matches. The regulations have been amended on the basis of feedback from doctors during the first two years of operation, but already the number of cases of non-compliance with the minimum requirements has dropped to 1.23 %, showing without doubt the commitment of all those involved in football to protecting the health of the players.

Sports science will continue to develop and innovate, bringing in new injury treatments and medical responses in the search for peak performance. The role of the doctor will be to manage this development, while always keeping in mind the ethics of sport. To protect our game, the doctor must continue to put the players' physiological integrity and psychological well-being above any other considerations.

This edition of Medicine Matters features articles on heat stress and football, regeneration and recovery from fatigue, and the age effect in Spanish professional football, as well as a report on the UEFA Elite Club Injury Study. It is a great pleasure to present to you such a wide range of articles, showing the great work that goes on within the European medical community. It is a community which European football is very fortunate to have.

Michel D'Hooghe
Chairman of the UEFA Medical Committee



Michel D'Hooghe

IN THIS ISSUE

HEAT STRESS AND FOOTBALL

By Prof. Gülfem Ersöz, Prof. Sadi Kurdak and Prof. Mehmet S. Binnet

It's not easy to keep cool when the heat is on

Football is the most popular sport in the world and is played by all kinds of people, regardless of their age, gender or physical condition. The physical aspects of football have been studied most intensively in adult male players, and a substantial body of information is available for this section of the population. In a typical football match, elite players cover a total distance of 9–12km, with an average aerobic load of 75 % of their maximum oxygen uptake (VO_2 max) and a heart rate of about 80–90 % of its maximum. It is clear that performance levels, and thus the outcome of matches, may be determined by the ability to perform repeated short bursts of high-intensity work in an endurance context, and the effects of heat stress or dehydration, either separately or in combination, may contribute to a decline in performance levels during a match.[1]

Stressful environmental conditions can pose numerous problems for athletes. Exertional heatstroke (EHS) is often associated with physical activity in a hot and humid environment, with incidence of EHS being correlated with rises in ambient air temperatures and humidity.

1. Extreme environmental heat places significant stress on the body's ability to perform, while thermoregulatory responses occur in various internal organs.
2. These responses include mobilising nutrients and electrolytes and maintaining an appropriate equilibrium within the body in terms of fluids, body temperature, pH and blood pressure. If the organs' internal systems do not respond appropriately, the athlete may develop a serious and potentially catastrophic medical condition.

To guard against EHS during athletic events, the American College of Sports Medicine (ACSM) has studied the effects of heat stress and made specific recommendations regarding participation in sport in stressful environments. Those recommendations consist of guidelines that measure and define the severity of heat stress using a wet bulb globe temperature (WBGT) index. On the basis of the WBGT at the time of the event, the ACSM also makes recommendations regarding the type, duration and frequency of exercise sessions on that particular day, the frequency of hydration and rest breaks, and whether or not the activity should be moved to a different time of day or cancelled altogether. Football is played in many different environments, and in some parts of the world competitive matches are played in challenging conditions, with temperatures exceeding 30C and a high degree of relative humidity.[2]

Hyperthermia imposes extra thermal stress on the player in addition to the usual physical stress. The core temperature of the player's body rises, the sweat rate increases as physiological defence mechanisms are used to dissipate the heat and reduce thermal stress, and fatigue ensues. The combination of an increase in the body's core temperature and progressive dehydration causes the player to become increasingly exhausted, leading to fatigue and, more importantly, the potential for adverse effects on the player's health.[3]

Testing of players at the end of a recent Australian rules football game that was played at an ambient temperature of 38C revealed a mean core temperature of 39.9C, so some individual values would have been well in excess of 40C.

The thermal stress that players face during a match has typically been estimated by simulating match conditions in a laboratory or a controlled indoor environment. However, football involves frequent fluctuations between high and low-intensity exercise, with a change of activity every four to six seconds, so the physical activity pattern of a football match may be quite different from the activities typically performed in laboratories. In addition, measurements made after a game may not truly reflect the changes in core temperature that occurred during the game.[4]

To reduce the number of heat-related illnesses, the National Collegiate Athletic Association recently introduced a mandatory five-day acclimatisation period. However, some research indicates that even longer acclimatisation may be needed. Several authors have suggested that an athlete requires approximately 10 to 14 days to fully acclimatise to environmental conditions and that the specific WBGT may not play a significant role in the incidence rate of heat cramps. Increasing the mandatory acclimatisation period in hot environments may reduce the incidence of exertional heat illnesses (EHIs). Based on the data collected, results indicate that most reported EHIs occur during the first three weeks of training in August, with a dramatic decline in incidence rates thereafter. This coincides with the beginning of football training and double training sessions. It appears that once double training sessions have ended, the incidence rate falls. The majority of the reported EHIs were heat cramps, which are typically associated with a lack of acclimatisation or conditioning.

Dehydration reduces endurance exercise performance, decreases time to exhaustion and increases heat storage[5]. EHS is characterised by rectal temperatures in excess of 40C at collapse and changes to the central nervous system. The following factors increase the risk of EHS or exertional heat exhaustion:

- obesity;
- low level of physical fitness;
- lack of acclimatisation to heat;
- dehydration;
- previous history of EHS;
- sleep deprivation;
- sweat gland dysfunction;
- sunburn;
- viral illness;
- diarrhoea;
- certain medication.

Physical training and cardiorespiratory fitness reduce the risk of EHS. In the event of EHS, immersion in cold water is the fastest way to cool the whole body down and produces the lowest morbidity and mortality rates. When immersion in water is not possible, placing ice packs and towels or sheets soaked in freezing cold water on the head, trunk and extremities results in effective – but slower – cooling of the body.

Dehydration and a high body mass index both increase the risk of exertional heat exhaustion, while 10–14 days of exercise training in the heat will improve acclimatisation to the heat and reduce the risk. EHS casualties may return to training and competitive matches when they have re-established their tolerance of heat. Aural, oral, skin, temporal and axillary temperature measurements should not be used to diagnose EHS or distinguish it from exertional heat exhaustion.

Early symptoms of EHS include clumsiness, stumbling, headaches, nausea, dizziness, apathy, confusion and impairment of consciousness. Training and competitive matches should be altered on the basis of air temperature, relative humidity, exposure to the sun, degree of acclimatisation to the heat, age and equipment requirements, by reducing the duration and intensity of exercise and by altering the kit worn.

Educating athletes, coaches, administrators and medical staff (especially on-site personnel and local emergency response teams) can help with the reduction, recognition and treatment of heat-related illness. Athletes should be advised about the importance of being well-hydrated, well-fed, well-rested and acclimatised to the heat. Athletes should also be told to monitor each other for signs of subtle changes in their performance or behaviour, making them responsible for monitoring each other's well-being[6].

1 Bangsbo J., Mohr M., Krustrup P., Physical and metabolic demands of training and match-play in the elite football player, *J Sports Sci*, 2006, Volume 24, 665-674.

2 American College of Sports Medicine position stand: Exertional heat illness during training and competition, *Medicine & Science in Sports & Exercise*, March 2007, Volume 39, Issue 3, 556-572.

3 Kurdak S.S., Shirreffs S.M., Maughan R.J., Ozgünen K.T., Zeren C., Korkmaz S., Yazici Z., Ersöz G., Binnet M.S., Dvorak J., Hydration and sweating responses to hot-weather football competition, *Scand J Med Sci Sports*, October 2010, Volume 20, Suppl. 3, 133-139.

4 Ozgünen K.T., Kurdak S.S., Maughan R.J., Zeren C., Korkmaz S., Yazici Z., Ersöz G., Shirreffs S.M., Binnet M.S., Dvorak J., Effect of hot environmental conditions on physical activity patterns and temperature response of football players, *Scand J Med Sci Sports*, October 2010, Volume 20, Suppl. 3, 140-147.

5 Maughan R.J., Shirreffs S.M., Ozgünen K.T., Kurdak S.S., Ersöz G., Binnet M.S., Dvorak J., Living, training and playing in the heat: challenges to the football player and strategies for coping with environmental extremes, *Scand J Med Sci Sports*, October 2010, Volume 20, Suppl. 3, 117-124.

6 Shirreffs S.M., Sawka M.N., Stone M., Water and electrolyte needs for football training and match-play, *J Sports Sci*, 2006, Volume 24, 699-707.

REGENERATIVE INTERVENTIONS USED IN PROFESSIONAL FOOTBALL

By Tim Meyer and Hugh H.K. Fullagar, Institute of Sports and Preventive Medicine, Saarland University, Germany

Means of supporting and hastening recovery after fatiguing stimuli are considered by many coaches and support staff to be a crucial tool for improving the effectiveness of football training and subsequent performance levels, while also reducing the risk of injury. To alleviate acute fatigue after strenuous training sessions or matches, several potentially recovery-enhancing methods and tools are available, including cold/contrast water immersion, sleep, appropriate nutrition, active recovery and massage. Although limited data is available, there are indications that both cooling by means of immersion in cold water and appropriate nutrition are effective, while theory suggests that active recovery and sleep (sufficient quantity and quality of sleep, combined with measures of sleep hygiene) could also enhance the recovery process. Even in the absence of solid empirical evidence, the placebo effect of many methods might be worth using, as long as relevant side effects can be ruled out.

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Whole body cooling

It is important for the medical staff of professional football teams to have an understanding of the evidence available for the various options, in order to be able to make a rational decision about the best method to implement and the best time to do so.

Cold/contrast water immersion

Water immersion is one of the most common recovery tools currently used by players. Generally, cold and contrast water immersion are the only effective forms of immersion. A recent literature meta-analysis conducted by Wigand Poppendieck and colleagues at the Institute of Sport and Preventive Medicine in Germany found that, in the case of elite athletes, these strategies are most likely to elicit recovery effects when they are applied to the whole body and when they are used after fatiguing sprint exercise. As football involves a large amount of high-intensity running, cold water immersion seems to be an appropriate method of supporting regeneration for football teams – at least for outfield players. In addition, localised cooling effects, psychological aspects and placebo reactions should also be taken into account. However, the physiological mechanisms driving cooling-based recovery remain fairly equivocal. Moreover, there are indications that continuous use of these water immersion strategies can be detrimental in terms of the desired training effect, though this remains inconclusive.

Cryotherapy

Another recovery method that is currently receiving a lot of attention from elite teams is whole-body cryotherapy – a type of cooling. The objective of this method is to prevent or treat muscle soreness and injury after high-intensity exercise through the application of very cold air (ranging from -100C to -140C) for one to several minutes within a cryochamber. Theoretically, cryotherapy aims to affect the inflammatory response after exercise and reduce the production of indicators of muscle damage (e.g. creatine kinase). However, the precise mechanisms involved are unclear. Further work is required to determine the optimum conditions, in order to produce effective cryotherapy protocols for individual players (duration, intensity, frequency, etc.). While cryotherapy – when applied properly – does not appear to produce any relevant negative side effects for athletes, there is a need for coaches and support staff to weigh the costs against the effects, as cryotherapy chambers cost tens of thousands of dollars. Also, they are not transportable, so they cannot be used after away matches.

Sleep

Since a variety of crucial metabolic and immune processes occur during sleep, there would appear to be a relationship between the quantity and quality of sleep and athletes' capacity to perform and recover (although evidence for footballers remains lacking). However, it is clear that there are instances where players' endogenous circadian rhythms and normal sleep-wake cycles can become desynchronised. For example, matches in the UEFA Champions League are almost always played in the evening. After some of these late games, players do not arrive back at the team hotel until around midnight, and some do not fall asleep for several hours. This sleep deprivation could potentially compromise recovery. Therefore, it is likely that extending the duration of sleep or optimising its quality during or prior to these periods will improve the ensuing recovery profile. However, further research is required to confirm this. While there is currently limited data available on sleep and recovery in football, individual sleep recovery strategies are recommended, due to the variability of individual requirements in terms of sleep.

Nutrition

From a refuelling perspective, carbohydrates are the most important nutritional requirement, as this is the macronutrient that is utilised most for the production of energy during football matches and training. Adequate amounts of carbohydrates (which will vary depending on the player's body weight and activity) should be consumed for up to three hours after a training session or match, while adding proteins/amino acids to recovery meals may also be advantageous. In contrast, there is no substantial evidence that vitamins or large amounts of electrolytes (besides those necessary for the taste and osmolarity of sports drinks) foster or support recovery. It is recommended that players avoid consuming alcohol, as this can negatively affect recovery by reducing the quality of sleep and interfering with glycogen resynthesis and fluid replacement.

Active recovery

Typically, football teams are advised to warm down as soon as possible after a match or the following morning. Very often low-intensity aerobic running is the chosen mode of active recovery. Alternative stimuli, such as cycling and swimming soon after exercise, are also implemented if they are logistically possible. The rationale for employing active recovery is improved clearance of metabolic waste products from the muscles involved, advantageous neuro-muscular reactivation after exhaustive exercise, and improved blood flow. However, whether this really shows that active recovery reverses fatigue is debatable. Notwithstanding this, active recovery strategies may at least distract the players from football and thereby foster some form of mental relaxation. This could potentially promote better sleeping habits and enhance recovery, but further investigation is required. When activities are planned for the day after a match, targeted training of less exposed muscles and non-physical stimuli represent an attractive alternative to low-speed running. Since there is no apparent detriment to recovery and there are a few theoretical benefits, active recovery seems advisable.


Sportsfile

Massage remains a popular form of recovery

Massage

Massage is a popular recovery strategy among football teams after matches and training. It is relatively uncomplicated, as the necessary facilities are available at almost every stadium and training ground, and professional football teams usually have their own physiotherapists. The most commonly used sports massage is the classic western (or Swedish) massage, including techniques such as effleurage, petrissage, friction, tapotement and vibration. There are several potential mechanisms involved (including physiological, biomechanical, neurological and psychological effects), but data on this is inconsistent. For example, there is little support for the argument that massage is effective in aiding football players' recovery. Nonetheless, massage may increase skin and muscle temperature, as well as alleviate delayed onset muscle soreness, and it may potentially improve muscle perfusion. A player's range of motion can also be increased using massage techniques if the elasticity of muscles and tendons is improved. Perhaps most importantly, a massage can have psychological benefits – e.g. aiding relaxation or improving a player's mood. As the mechanisms involved are unclear and there is no empirical proof of improved performance, the use of massage as a means of recovery can be based on the individual needs and preferences of the player, because negative side effects are unlikely.

Other commonly used recovery strategies

Of course, there are a variety of other potential recovery-supporting tools, most of which are less attractive in the specific environment of professional football. One of the more frequently

Chelsea FC/Press Association Images

Some teams use ice baths to aid recovery

used tools is compression garments. However, from a theoretical perspective, these are a tool to be employed while playing football (as long as this is in accordance with the relevant rules), as the avoidance of tissue oedema and the concentration of blood flow to the working muscles are the proposed mechanisms. Therefore, the main purpose of such compression garments use is to delay exhaustion, not to enhance recovery. Nevertheless, they are also applied after training and competitions, despite there being no solid evidence in support of this practice. It is noteworthy that there are plenty of anecdotal reports indicating that muscle soreness might be decreased by wearing compression garments also after activity.

Interaction and potential side effects of regenerative interventions

Although many football players use more than one recovery method to achieve additional benefits, it is unclear whether this may lead to interaction between the various methods. Such interaction may be advantageous if the effects of the two interventions complement each other. Indeed, they may even potentiate each other. A typical example of such positive interactions is the combination of carbohydrates, fluid replacement and active recovery. At least theoretically, increasing blood flow to the working muscles, combined with the slight positive rheological effects that fluids have on circulation, should support glycogen resynthesis in the active muscles. However, it is also possible that cooling down working muscles using cold water immersion interferes with these beneficial regenerative processes. The most appropriate combination of recovery methods remains largely open to speculation, because very little research has been conducted in this area. Plausible physiological thinking is the best recommendation at the moment.

Regenerative interventions between training sessions and/or competitive matches are deemed effective when the duration of fatigue is reduced. This can be used to apply the next training stimulus earlier, or at the same time in a more intense manner. However, repeated use of recovery-supporting methods may also lead to a net reduction in the training stimulus if the original training schedule is maintained and not adapted in line with improvements in recovery. Therefore, overly frequent use of those recovery-enhancing tools that are deemed effective does entail a risk. Weeks with congested competition schedules (e.g. Saturday – Tuesday – Saturday) are an appropriate time to use methods supporting quick recoveries – at least for those players who have spent significant amounts of time playing. In contrast, there is less need for regeneration during the preparatory phase, as a certain degree of fatigue is required over time to facilitate training-induced physiological changes. Therefore, the use of recovery tools is very much dependent on the stage of the season.

Summary

When considering tools or methods that support and hasten recovery in professional football, scientific evidence is limited. The methods with the strongest empirical evidence are cold water immersion and appropriate nutrition. There is also strong theoretical support for the importance of sleep (sufficient quantity and quality of sleep, with measures of sleep hygiene) and active recovery. Although in many cases there is no scientific evidence of a direct effect, there may nevertheless be a considerable placebo effect, which can be advantageous and even desirable, as long as relevant side effects are unlikely. This points to the need for recovery strategies to be tailored to individual players and to take into account that perceptual and psychological may be as important as physiological recovery.

THE RELATIVE AGE EFFECT IN SPANISH PROFESSIONAL FOOTBALL

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Rev.int.med.cienc.act.fís.deporte- vol. - número - - ISSN: 1577-0354 / (Journal of Sports Science of Medicine. (2013). In press. Ref: artefectos 514)

The purpose of this study was to see whether there is a relative age effect in Spanish professional football, where there is a cut-off age for classification that is based on the calendar year. The relative age effect was also examined in relation to players' positions. This analysis looked at all footballers playing in the Spanish Liga during the 1999/2000, 2008/09, 2009/10, 2010/11 and 2011/12 seasons.

The results of our study confirmed the existence of a relative age effect in Spanish professional football in the last four seasons considered, but did not point to any such effect in the 1999/2000 season. When the effect is broken down by position, it is apparent among defenders and midfielders during those four years.

Introduction

When the classification of sportsmen and women is based on their date of birth, individuals can experience various advantages and disadvantages depending on their date of birth. Such effects arising from an individual's date of birth have been termed the "relative age effect" (RAE) and have been examined in various studies (Wattie, Cobley and Baker, 2008). Barnsley, Thompson and Barnsley (1985) are credited with originally identifying this phenomenon. In one study looking at elite Canadian hockey, it was discovered that, across the various teams, nearly 40 % of players were typically born in the first three months of the year.

In the world of football, various studies have been conducted with a view to investigating the relative age effect. Barnsley, Thompson and Legault (1992) published the first research identifying the relative age effect in football, looking at Under-20 and Under-17 players participating in the FIFA World Cup in 1990. A similar effect has been found in professional leagues in various countries around the world, including Germany, Japan and Brazil (Musch and Hay, 1999), Belgium (Vaeyens, Philippaerts and Malina, 2005) and Spain (Lesma, Pérez and Salinero, 2011; Salinero, Pérez, Burillo and Lesma, 2013). Particular attention should be paid to the work of Helsen, Hodges, Van Winckel and Starkes (2000), who found that changing the cut-off date for classification from August to January resulted in a demonstrable change in the players selected, with more from the first half of the calendar year and fewer from the second half. Within a relatively short period of time, very few players born during the final three months of the year were being selected. It is also important to mention the work of Helsen, Starkes and Van Winckel (1998), who found evidence that players born in the last few months of the year tended to stop playing if they were not selected.

Different dates of birth entail differences in physical maturity, which can influence team selection. García and Salvadores (2005) found differences of 10cm in height and 10kg in weight among 14-year-old players born within the same calendar year. Similarly, a study conducted in France involving elite young players (Carling, le Gall, Reilly and Williams, 2009) found that those born in the first three months after the cut-off date for classification had advantages in terms of height, weight, maximal quadriceps strength, maximal anaerobic capacity and estimated VO_2

Do players born early in the year have the edge?


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max. In a study involving 281 hockey players aged 14 and 15, the players who were selected for teams were taller, heavier and more likely to be born in the first half of the year (Sherar, Baxter-Jones, Faulkner and Russell, 2007). In another study involving young footballers, differences in height were found to result from the timing of birth, even when biological maturity had been controlled (Hirose, 2009).

The relative age effect becomes a major issue during adolescence as a consequence of age-related differences in physical maturity. The RAE issue has been identified by researchers in various countries, such as the United States (Vincent and Glamser, 2006), Brazil (Rogel, Alves, França, Vilarinho and Madureira, 2007), France (Carling *et al.*, 2009), Spain (González, 2007; Gutierrez, Pastor, González and Contreras, 2010; Perez and Pain, 2008; Salinero *et al.*, 2013) and Belgium (Helsen, Van Winckel and Williams, 2005). According to Cobley, Baker, Wattie and McKenna (2009), the RAE is probably particularly influential in popular male sports involving participants between the ages of 15 and 18. Nonetheless, the most talented players can still stand out, irrespective of their date of birth, as noted by Ford, Webster and Williams (2008), who analysed 180 athletes who had achieved very considerable degrees of sporting success. They concluded that the RAE did not affect these athletes, but that among athletes with more common technical and tactical capabilities, increases in physical capacity can be linked to their date of birth, which can prove to be the determining factor in their selection.

At lower age levels, the selection process is influenced by the relative age effect, meaning that there will be more players born earlier in the calendar year. This inevitably means that there will be a higher probability of the same players participating at higher age levels. It is reasonable to think that these physical differences will influence team selection and the positions of individual players, given that goalkeepers and defenders tend to be bigger than other players (Gil, Gil, Ruiz, Irazusta and Irazusta, 2007; Reilly, Bangsbo and Franks, 2000). Nonetheless, none of the studies that have been conducted to date in Spain have found that the relative age effect influences playing positions in youth football (Gutierrez *et al.*, 2010).

The objective of the present study was to confirm the presence of the relative age effect in the top division of Spanish football and to see whether it also influenced playing positions.

Materials and methods

Sample

The study looked at all players participating in the Spanish Liga over five seasons: 1999/2000, 2008/09, 2009/10, 2010/11 and 2011/12 (a total of 2,430 players; see Table 1).

Table 1. Participants included in overall sample

Season	No of players	Percentage
1999/2000	472	19.4
2008/09	478	19.7
2009/10	481	19.8
2010/11	482	19.8
2011/12	517	21.3
Total	**2,430**	**100.0**

Data sources

Information on dates of birth and playing positions was obtained from the web pages of the various teams participating during these five years and triangulated with information from the Marca guide for each season.

Data analysis

The statistical analysis was carried out using the statistical program SPSS (version 18) for Windows. Through this analysis, birth date frequencies were obtained and the chi-square statistic was calculated to examine the homogeneity of the distribution of birth dates across the four trimesters.

Results

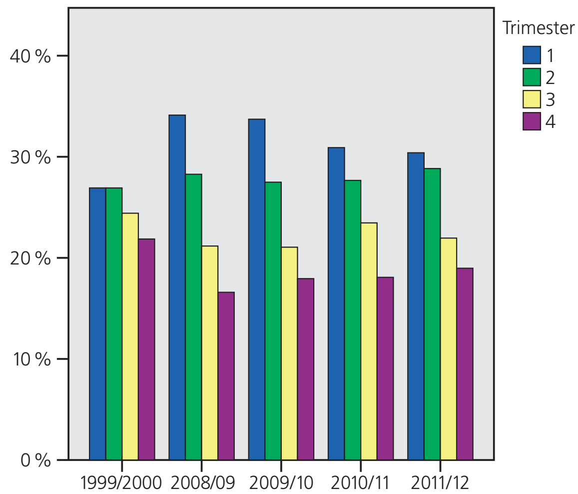


Figure 1. Distribution of players' birth dates across the four trimesters

Figure 1 presents the distribution of players' birth dates across the four trimesters for the five seasons in question. We can see from Figure 1 that the season with the greatest amount of homogeneity across the trimesters was 1999/2000, while the 2008/09 season produced the largest differences, and there has been a progressive decline in the proportion of players born in the first half of the year since 2008. The chi-square statistic and associated significance levels for each season are reported in Table 2.

Table 2. Chi-square values and statistical significance of differences across trimesters for each season

Season		
1999/2000	Chi-square	3.420
	df	3
	Signif.	0.331
2008/09	Chi-square	34.435
	df	3
	Signif.	0.000
2009/10	Chi-square	28.480
	df	3
	Signif.	0.000
2010/11	Chi-square	17.817
	df	3
	Signif.	0.000
2011/12	Chi-square	17.825
	df	3
	Signif.	0.000

Significant heterogeneity was found in the four most recent seasons ($p = 0.000$), with players born in the first three trimesters being over-represented relative to players born in the last three months of the year. Nonetheless, in the 1999/2000 season, there was no significant RAE ($p = 0.331$).

If we look at individual playing positions, we find that players born in the first three trimesters of the year are over-represented in certain positions, most notably among defenders and midfielders (see Figures 2 to 6).

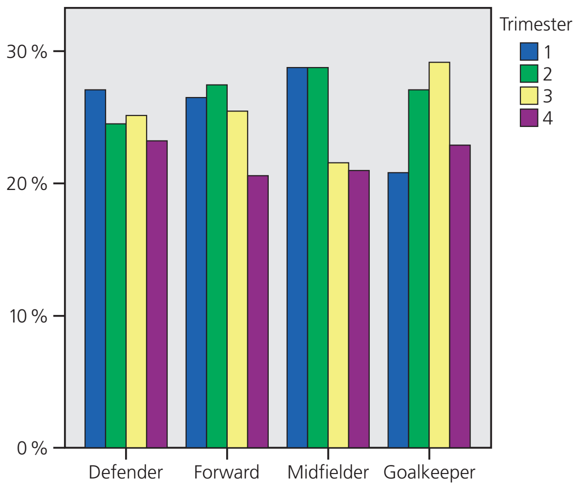


Figure 2. Distributions for individual positions for the 1999/2000 season

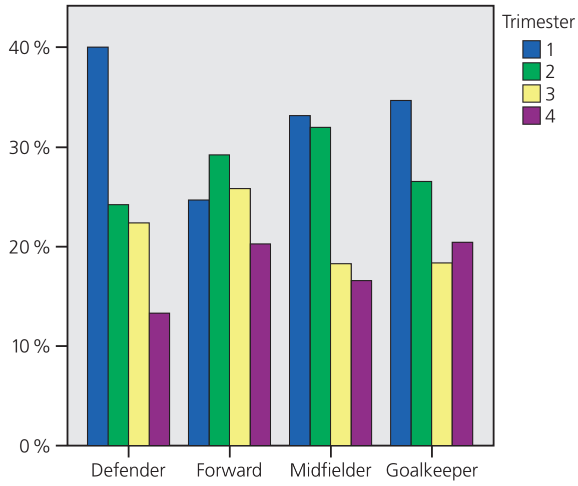


Figure 3. Distributions for individual positions for the 2008/09 season

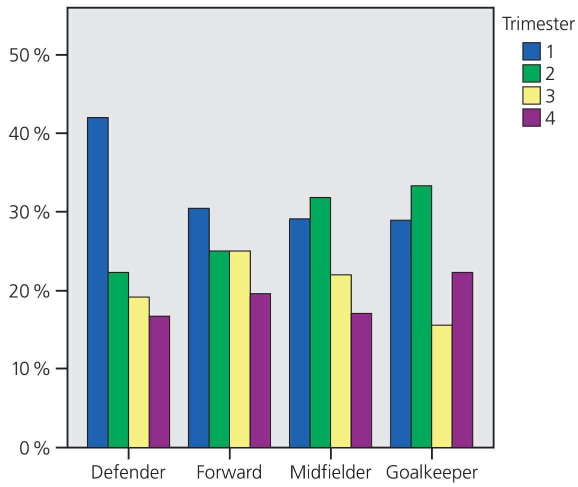


Figure 4. Distributions for individual positions for the 2009/10 season

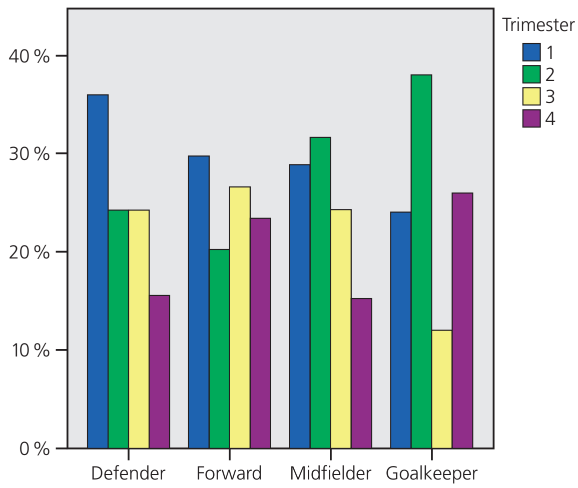


Figure 5. Distributions for individual positions for the 2010/11 season

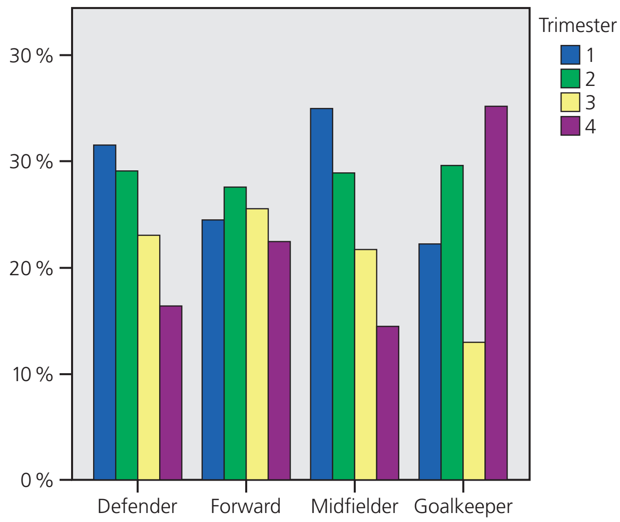


Figure 6. Distributions for individual positions for the 2011/12 season

Statistically significant heterogeneity was found for defenders and midfielders during the four most recent seasons, but no significant heterogeneity was found for the 1999/2000 season in any position. In the case of goalkeepers and forwards, there was no significant relative age effect in any season (see Table 3).

Table 3. Chi-square significance by position across the various seasons

	DF	MD	FW	GK
1999/2000	0.922	0.289	0.768	0.841
2008/09	0.000	0.001	0.689	0.367
2009/10	0.000	0.019	0.537	0.352
2010/11	0.003	0.012	0.590	0.079
2011/12	0.028	0.001	0.912	0.112

Discussion

A snapshot of the relative age effect at any level of competition may reveal some differences (Lesma *et al.*, 2011; Musch and Hay, 1999; Wiium, Lie, Ommundsen and Enksen, 2010), but there is little doubt that taking a longer-term view results in greater insight into the relative age effect.

The relative age effect was detected in the four most recent seasons – in contrast with the 1999/2000 season, when there was much less heterogeneity, with only a 5.1% difference between the first and last trimesters. By the 2008/09 season, this had increased to 17.6%, but by the 2011/12 season it had fallen to 11%. Thus, the effect appears to be gradually declining over time. The RAE that we found in the 1999/2000 season was very similar to the findings obtained three seasons later by González (2007): 54.7% of players were born in the first half of the year, slightly lower than the figure for the 2008/09 season if both the first and second divisions are included in the analysis. These findings suggest that the RAE in Spain has fluctuated somewhat, increasing strongly as of 2000 before levelling off and then declining slightly.

Data analysis also reveals variation in the relative age effect depending on playing position. A previous study looking at young footballers (Gutierrez *et al.*, 2010) did not find such differences, but in the present study, which looked at professional players who had reached the highest level of Spanish football, the findings were clear.

There are differences in height across the various playing positions, with goalkeepers and defenders tending to be taller than midfielders (Gil *et al.*, 2007; Reilly *et al.*, 2000; Shephard, 1999), which would suggest that the RAE should be found among goalkeepers and defenders. In the present study, though, the RAE was greatest for defenders and midfielders, and it was not found at all for goalkeepers. This could be linked to the peculiarities of Spanish competitions and the styles of play of the teams.

Previous studies that found that midfielders were shorter than players in other positions (Reilly *et al.*, 2000; Shephard, 1999) were conducted in countries where the style of play is different and play tends to be at a lower competitive level (Gil *et al.*, 2007).

Whatever the circumstances, we suggest that, in light of the findings of the present investigation, it is absolutely essential that there be changes to both the process by which younger players are selected and the selection system currently used by professional teams.

Alternative approaches have been proposed, including changes to clubs' organisational structures (Gutierrez, 2013), but the problem is complex and will require both short-term and long-term changes.

One approach involves taking a longer-term view in sport development programmes, with consideration being given to both athletic potential and scope for development.

Not only would this result in more consistent and fair programmes for the youngest players, but sports clubs could also optimise their results, including their economic outcomes, by making the appropriate investment in the development and promotion of their own players, rather than relying on the acquisition of players from other clubs. In our opinion, given the apparent social and economic implications of these changes, future research could be directed at estimating the socioeconomic impact of addressing the relative age effect in professional football.

THE UEFA ELITE CLUB INJURY STUDY: A UNIQUE RESOURCE

Injuries are a common occurrence in football. However, at elite level, they can have significant consequences if they mean that a player misses a key fixture or – worse – a considerable part of the season. Since the start of the professional era, FIFA, UEFA and the national associations have consistently worked to ensure the safety of players, and in 2001 UEFA launched a research programme with the aim of not only increasing players' safety through the monitoring of injury patterns, but also contributing more broadly to the understanding of sports injuries through scientific studies and publications. This project, the UEFA Elite Club Injury Study, has been running for the last 12 years, with data taken from elite clubs in the UEFA Champions League, and findings and trends regularly reported to the participating teams and published in scientific journals such as the British Journal of Sports Medicine for the good of the game and sport in general.

The aims of the Elite Club Injury Study are broadly the same as they were when the project was first conceived at a meeting of the UEFA Medical Committee in Bruges on 6 October 1999, when, in light of the concerns expressed by the UEFA President at the previous meeting regarding the number of matches played by top-level players, Professor Jan Ekstrand was asked by the committee to draw up a protocol for a possible pilot study looking at injuries sustained by players at the highest level of the game. The intention was that the results of the study would be used to devise measures preventing injury, to ascertain the degree of exposure to football in the various European countries (looking, for example, at the ratio of training sessions to matches), to analyse injury patterns in different teams, to look at differences between countries, and to evaluate the risk of injury, bearing in mind the question of exposure. The aims of the initiative have evolved slightly over the years, but the main focus is still on using the data collected for the good of the game as a whole. The study's current aims are as follows:

- to evaluate injury risk and the circumstances surrounding different injuries, looking at exposure during training sessions and matches;
- to analyse injury patterns and look at the severity of injuries;
- to compare data on injury risk and injury patterns with data from previous years;
- to contribute to UEFA's injury database, and to monitor trends in injury risk and injury patterns over time.

Participating clubs

The annual study is conducted over the course of the European football season, starting in July each year. At the start of the 2013/14 season, there were 33 clubs from all over Europe participating in the study. All but four of the teams that have reached the semi-finals of the UEFA Champions League since the 2001/02 season have submitted data to the study, making it a truly elite sports study. Injury studies have also been conducted at the final rounds of UEFA youth competitions, and a study is always conducted at the UEFA EURO (the next being UEFA EURO 2016 in France).

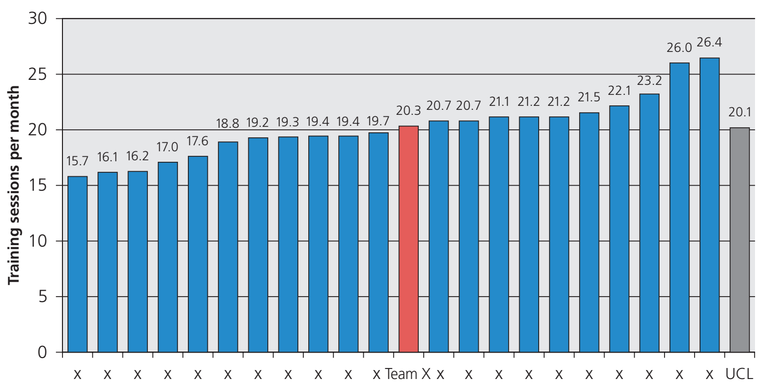
Jan Ekstrand, vice-chairman of the UEFA Medical Committee and head of the Sweden-based Football Research Group, which oversees the study, notes: *"The clubs give us their data on injuries that cause absence from training and matches, as well as data about players' exposure. Our database is the largest of its kind in the world, and it allows us to send lots of information back to the clubs – for example, data about how long it takes for certain injuries to heal, what the trends are, and which clubs are effective in keeping players on the pitch."*

Data collection

Data is collected using standardised forms, with all participating clubs required to submit training and match injury data to the Football Research Group every three days. The study has recorded a total of 8,921 injuries and 105,720 hours of exposure in its first 12 seasons. Injury is defined as any physical damage occurring during a football-related activity (i.e. a scheduled match or a training session) which results in the player being unable to participate fully in a future training session or match.

All participating clubs receive mid-season and end of season reports showing injury trends with previous seasons. The reports also compare clubs' injury records with those of other teams in the study (which are listed anonymously). This allows clubs to review their own performance and adjust their medical operations and training programmes where required. Also useful in this respect is a 'pursuit of excellence' summary sent to all clubs, where tips and techniques are shared in an attempt to raise overall knowledge levels within the game.

Figure 1: Number of training sessions per month



Notes: Each club (here, Team X, marked in red) is provided with a version of the report that shows its position relative to other clubs, which are listed anonymously. The final column shows the average for all clubs.

A wide range of practical information on injuries

Thus far, the study has produced information on issues such as the correlation between increasing load and injuries (i.e. the effects of playing too much football), the relative effects of playing on artificial turf and grass, the periods during a 90-minute match when certain injuries are more likely to occur, and whether injury risks for players are higher at certain points in the season. For a club wanting to know how many instances of each different type of injury it will be likely to encounter during a season, statistics such as the table below can be invaluable, helping the club's management to see how well its medical department is performing relative to other elite clubs.

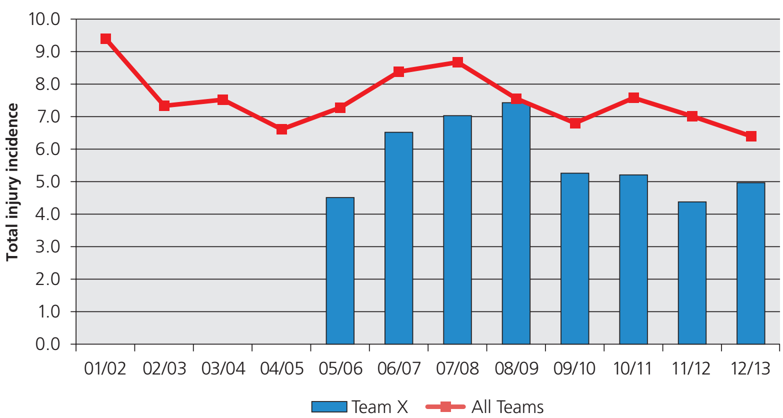
Figure 2: Injuries reported by clubs during the 2012/13 season

	Training				Matches				Total			
	Team X		Other teams		Team X		Other teams		Team X		Other teams	
	N	%	N	%	N	%	N	%	N	%	N	%
Fracture	1	7.1	9	2.3	2	9.5	20	4.2	3	8.6	29	3.4
Other bone injury	0	0	3	0.8	0	0	3	0.6	0	0	6	0.7
Dislocation/subluxation	1	7.1	4	1.0	0	0	11	2.3	1	2.9	15	1.7
Sprain/ligament injury	1	7.1	40	10.3	5	23.8	91	19.1	6	17.1	131	15.1
Meniscus/cartilage	0	0	14	3.6	0	0	11	2.3	0	0	25	2.9
Muscle rupture/strain/cramps	6	42.9	152	39.1	5	23.8	180	37.8	11	31.4	332	38.4
Tendon injury/rupture/tendinosis	2	14.3	39	10.0	2	9.5	29	6.1	4	11.4	68	7.9
Haematoma/contusion/bruise	1	7.1	32	8.2	6	28.6	58	12.2	7	20.0	90	10.4
Abrasion	0	0	2	0.5	0	0	0	0	0	0	2	0.2
Laceration	0	0	2	0.5	0	0	2	0.4	0	0	4	0.5
Concussion	0	0	0	0	0	0	2	0.4	0	0	2	0.2
Nerve injury	0	0	3	0.8	0	0	4	0.8	0	0	7	0.8
Synovitis/effusion	0	0	7	1.8	1	4.8	11	2.3	1	2.9	18	2.1
Overuse, unspecified	2	14.3	44	11.3	0	0	30	6.3	2	5.7	74	8.6
Other injury	0	0	38	9.8	0	0	24	5.0	0	0	62	7.2
Total	**14**	**100**	**389**	**100**	**21**	**100**	**476**	**100**	**35**	**100**	**865**	**100**

Using the data

If clubs are to manage their injuries, it is essential that they understand this data and can use it to evaluate incidence rates or see how likely an injury is to occur. Data such as that shown in Figure 3 not only tells participating clubs how their current incidence rate compares with previous seasons, but also shows how close they are to the mean incidence rate for all clubs taking part in the study.

Figure 3: Total injury incidence over 12 seasons



Notes: Red line shows average incidence across all participating clubs. Blue bars show the incidence rates for a specific club – Team X.

The study has recorded a total of 8,921 injuries in its first 12 seasons

Information gathered using data from the injury study shows that, since 2001, UEFA Champions League finalists have missed 13% fewer matches in those seasons where they have reached the final, compared with other years. The number of muscle injuries suffered during matches is also 24% lower in those seasons, despite the fact that they have played the maximum number of high-intensity games, where the risk of injury is increased.

FC Barcelona have been contributing to the study since its inception. Their club doctor, Ricard Pruna, notes: *"Currently there is 12 years of data and many other statistics, allowing comparison with other clubs in terms of muscle injuries, tendonitis, serious or slight injuries, ligament injuries and player availability. We use these statistics to educate the players and talk to the coaches to draw conclusions and improve for the following season. We know today that if we go past a certain number of injuries, we won't win the Champions League; it's impossible. That's a fact. When we won the last two Champions Leagues – I especially remember the one in Rome in 2009 – Barcelona had six muscle injuries. That's a very low number. In other seasons, where the club has maybe only won the Spanish Cup, but not the Champions League or the Spanish Liga, instead of those 6 muscle injuries we had maybe 40."*

The study will continue in the 2014/15 season, with new clubs becoming involved, such as FC Basel 1893 (the first participants from Switzerland). UEFA and the Football Research Group hope to continue to welcome new participants in the future, to further increase the scope and quality of the football injury database, and to further improve the understanding of how injuries can affect players' health and teams' performance. Teams and supporters can no longer blame luck for their level of injuries, when science clearly shows that an elite club which takes steps to prevent injuries and manage them when they occur is far more likely to enjoy success on the field than a team which does not.

Professor Ekstrand notes: *"The clubs don't send us data just to be nice to UEFA or us; they do it because the information they get back is advantageous for them in terms of keeping players on the pitch, and we have shown that if you can keep the players on the pitch, keep availability levels high, there is a bigger chance of success and good results for the team. This seems an obvious point, but without the study we would have no scientific proof."*