
PRACTICAL APPLICATION

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Fluid Balance Testing for Elite Team Athletes: An Interview with Dr. Susan Shirreffs

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The papers in this issue of *IJSNEM* include a study by Dr. Bob Oppliger and colleagues on issues associated with the monitoring of urine (specific gravity and osmolality) as a measure of an individual's hydration status. This work reflects the recent interest in capturing "real life" information about athletes' hydration practices during exercise or over the day. Sports scientists and sports nutritionists are eager to find tools and techniques that can be used in the field to provide timely feedback to athletes about their fluid intake strategies. In this interview, Dr. Susan Shirreffs from Loughborough University provides advice about the value and issues involved with undertaking "sweat testing" on athletes

Susan, your doctoral work focused on strategies to promote the restoration of fluid balance after dehydration. But more recently, you've been undertaking sessions to monitor the fluid balance characteristics of team athletes during training. Are you able to name some of the teams that you have studied?

I have been to a number of European football teams, or soccer teams as many readers would refer to them! Many of these teams are happy for their names to be mentioned and indeed for results to be published in the scientific literature. The well known teams that immediately spring to mind are Manchester United from England, Real Madrid from Spain, and Ajax from The Netherlands. But we have also been to some less well known European clubs. Other than men's football we have also made measurements on the England Under 21 women's hockey and football teams. Our most recent measurements were on two opposing football teams in a competitive match in England. We hoped to get good measurements on a minimum of 22 players—the starting 11 from each team—but the game was highly competitive and 2 players were sent off during the game, one within the first 10 min, before he had sweated sufficiently for us to get enough sample!

What type of information have you been able to collect over a session?

We typically start by getting a urine sample from the players when they are getting changed before the start of their training session. We use this to get an indication of their hydration status using measures of osmolality or specific gravity or by determining its color. We work out how much they drink over the session by weighing drink bottles before and after the session—watching closely during the session to ensure they

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all drink from only their own bottles. We have been in situations where it is common practice for players to frequently rinse their mouth with water from drink bottles then spit it out. When we suspect this is going to happen we provide separate water bottles for this. From body mass changes we estimate sweat losses taking account of how much has been drunk and any urine that has been passed during training. We always make sure we have plenty of containers at the session to collect any urine the players need to pass at any time between the body mass measurements. As yet we've not had anyone who wants to break from training to defecate! The last thing we collect is sweat samples so we can get an estimate of sweat electrolyte losses.

And what equipment do you need for each of your measurements?

To the "field" we take scales that weigh to the nearest 20 g to measure the players and scales that measure to the nearest 1 g for measuring drink bottles and urine samples to work out the volume of each. When we want to turn round the pre-training hydration status results quickly we take our osmometer with us, but sometimes we just take samples back to the lab. We never make any measurements on the sweat samples at the field. The only other equipment we take with us is for measuring the environmental conditions and the consumables we need for collecting samples. Back in the lab we analyze the sweat samples either on our flame photometer, if we only want sodium and potassium concentrations, or on our ion chromatograph if we want a whole range of anions and cations.

What steps do you need to take to set up such a monitoring session in a team sport? Who do you need to have on your side?

Good communication with someone at the club is key to a successful session and things also work best if you get pivotal senior players on your side—the captain and the like. It seems inevitable that when we test a squad of 20 to 30 players there are always some players who are not particularly interested in what we are doing and what information it may provide them with while others get involved in great discussion about the potential outcomes.

What sort of instructions do you need to give to the players, trainers, or other people involved in the team to ensure that it runs smoothly and that the information that you collect is meaningful?

We first try to emphasize that we don't want our presence to change the activities of the players—we want the training session to be as it would normally be with the normal availability of drinks in terms of types available and encouragement and opportunities to drink during training. Another key message we need to get across is that if anyone needs to urinate between the two body mass measurements we need to collect it. At some clubs this doesn't seem to happen but at others players regularly disappear to urinate. We need to make sure someone is close by with a container!

What can happen on a "bad day" of testing?

On a bad day of testing we can run short of time for getting pre-training measurements made and sweat patches applied. Things then get tense, because coaches can get unhappy if the players are not out on the pitch ready to start when they should be. Other than that, some sweat patches getting dislodged, missing collection of a urine sample, or players

spitting out their drink after rinsing their mouth tend to be the biggest problems. We avoid these as best we can by having our testing team located at various places around the training ground keeping close watch of what is happening.

What have you found about the sweat losses and fluid intakes of the players you've studied?

The huge variation in sweat losses and drinking behavior from a group of players all doing the same training, at the same time, in the same condition is always striking. Most of the players we have tested have been male. Over a 90 min training session the largest sweat volume we have recorded is more than 3 L with the smallest being less than 1 L. These are both from outfield players. The drink volumes we have recorded have ranged from virtually nothing to more than 2 L in this time. On average, across all the male squads we have tested, we calculate that the players end up dehydrated to a greater or lesser extent after training.

Many of the teams you've dealt with would be considered the most "professional" in the world—lots of money involved, sponsorship from sports drink companies, well-credentialed sports science/medicine support, and important outcomes on the line. Under these circumstances you'd expect "world's best practice" when it comes from something that seems as simple as drinking during training sessions. How do you explain the failure of some players to drink at a rate that keeps pace with sweat losses?

There is no doubt that lots of money is involved. I heard on the radio today that one of the players we tested at one of the clubs is to be paid as much in 1 wk as would take me three and a half years to earn—and that is before taking into account his sponsorship deals. And I know for sure he is not the highest paid of the players we have tested! If a player turns up for training well hydrated, I think they can cope with a bit of dehydration developing over their training session with no problem. The concerns arise when they are already dehydrated when training starts so that over training they become significantly dehydrated. Or if they are a very heavy sweater, a rate of more than 2 L/h. During competitive matches there tend to be limited stops in play that give adequate time to allow for players to drink, and it is seldom that you see a player look for an opportunity to drink during play. I suspect this culture carries across to the training, too.

What have you learned about sodium and electrolyte losses during training sessions? How high are the losses in some individuals, and what advice do you have for these players?

It's back to the huge variation again. We regularly find players with sweat sodium concentrations close to the top of what I would consider to be the normal range—around 80 mmol/l and others right down at the bottom of the range—around 10 mmol/l. This combined with varying sweat losses means that we estimate there is a huge range in the amount of sodium players lose, from fractions of a gram to considerable quantities—up to around the equivalent of a teaspoon of salt!

Do you have a feel for the theories proposed by some sports scientists/physicians that high sodium losses may be associated with an increased risk of cramping?

I don't have any hard data that I could show you to provide evidence but the relationship has come up anecdotally on a number of occasions at a variety of different clubs. What

I mean is that if I ask a team doctor if any of his players are prone to cramp, particularly pre-season or at the end of the season when the weather is warmer, these players are frequently the ones with sweat sodium concentrations close to the top of the range. At one club a player got cramps during the session we were monitoring. He lost the most sodium of all the players tested that day. More systematic research is needed, though.

Your data has appeared in peer-reviewed publications, but presumably you also provided feedback to the athletes and coaches at the time you collected it. How and when did you provide information to the team?*

We try to provide feedback as soon as possible—before the players forget we were there and why we were there! Body mass changes, drink volumes, sweat losses, and change in hydration status can be calculated quickly, while still at the testing site, and fed back immediately. We cannot get any data on sweat electrolyte losses until we are back at the lab, but we can then get data back to the club and players within a couple of days. We have used various methods of feedback. Typically, we put together a 1 page feedback sheet for each individual player containing their own data, our interpretation of it, and personalized advice for them. We also put together a summary sheet for our medical or scientific contact at the club containing all the data we collected. We then liaise with our club contact as to what they feel will work best for their players—typically they get the written feedback plus a meeting with their club doctor, scientist, dietitian, or nutritionist or perhaps a talk from us.

Have you observed any players in the teams you've monitored who consume excessive amounts of fluids during training—that is, amounts greater than their sweat losses? Do you think it is important to educate team athletes about the dangers of over-hydration during exercise?

We have seen people gaining weight over their training session when we have been monitoring. As a rough estimate, from the 200 or so males we have monitored maybe 5 to 10 have drunk more than their sweat loss. But from their pre-training urine osmolality measurements I suspect some of them did not start training euhydrated. From the 30 or so female players we have measured we have seen the majority gaining weight. It is something we need to follow up on and investigate further. There is always the possibility that some people change their behavior simply because they know they are being monitored even though we try to prevent this. Nonetheless, we have never seen the situation of anyone overdrinking to extreme in any of the sessions we have monitored. The mass gains we have seen have been no more than a few hundred grams at most.

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Do you have any final advice for sports scientists or nutritionists who would like to conduct "sweat tests" for the teams they work with? How can you sell the value of this type of work?

Be professional, but have fun and enjoy it! And learn as much as you can by watching and listening closely to what is going on. I think the value of this type of work is that it treats people as individuals. We all have a different physiology. Just because players are in the same team doesn't mean they should be treated the same from a nutrition and physiology point of view.