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Fluid Guidelines for Sport: Interview With Professor Tim Noakes

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Over the past two decades, Professor Tim Noakes has championed the case for a change in the way we educate athletes about fluid intake during sport and exercise. In particular, readers are directed to a recent publication: Noakes, T.D. and D.B. Speedy, 2006. Case proven: exercise associated hyponatraemia is due to overdrinking. So why did it take 20 years before the original evidence was accepted? *British Journal of Sports Medicine*, 40:567-572. In this interview, I ask Professor Noakes to further develop some of the themes that have convinced us to refine fluid intake guidelines, and to explain some of his more controversial beliefs or statements.

Professor Noakes, you have been instrumental in bringing and maintaining our attention to the issue of hyponatremia in endurance and ultra-endurance sports. Although there is still some debate between some parties about all the potential mechanisms by which hyponatremia might occur, it seems clear that the most severe cases occur as a result of "overdrinking"— drinking fluids in amounts that are substantially greater than sweat losses and in excess of the body's ability to excrete urine. Your counter to this is that we should educate athletes to only drink according to their thirst. In other words, if you feel thirsty during exercise, drink. If you aren't thirsty, don't drink. I have some concerns about the precision of this advice to some individuals. It seems to me that today's nutrition crises at a population level arise because people have lost their sense of portion control, and their ability to read their body's appetite. When I go to the US, I am continually offered the opportunity to "up size," and I can buy a 32 oz. drink (1000 mL) as a single serve. Can you be sure that some of the overdrinking behaviors won't continue to occur because some individuals lack the tools or knowledge to react properly to true thirst?

Your point really emphasizes the problem. When athletes were advised not to drink during exercise, as was the case when I began running in 1969, there were no cases of overdrinking during exercise. Athletes were specifically told that to give in to their thirst was a sign of weakness. Whether or not this advice produced its own problems is open to debate. But the point is that athletes were told that they must

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ignore those biological cues that normally regulate drinking behavior. So perhaps it was to be expected that the new guidelines that became popular in the early 1980s continued to advise athletes that they must still ignore their intrinsic physiological cues. But now, instead of not capitulating to their thirst, they must do the opposite. So they must stay "ahead of thirst" since by the time they become thirsty they are already "dehydrated" and at risk of all sorts of dire medical consequences. Athletes were also encouraged to "drink as much as tolerable" without being warned that over-drinking could be fatal.

It seems to me that the advice to "stay ahead of thirst" or to "up size" is a symptom of the same problem—the influence of a consumerism that is focused on profit, not on human health. What athletes perhaps need to be told is that they would be better advised to listen to their bodies than to the marketing spin generated on Madison Avenue. The problem of course is that the influence and reach of product marketing far exceeds anything we scientists can do with our more meager resources. But as soon as we send out a consistent message that is truly independent of commercial interests, we do become a far more powerful global influence. The problem is that the message sports scientists have been giving for the past 20 years is inconsistent and this inconsistency has been exploited by industry.

Indeed this is shown in the example you have used. In the past I have been told that my advice that athletes should drink only according to the dictates of thirst can be very dangerous since athletes who follow this guideline will become "dehydrated" and hence risk their health and their performance during exercise. Now I agree that there is the real concern that some athletes are so confused that they will continue to over-drink even when told to drink only according to their thirst, simply because almost all the information they have received in the past 20 years has encouraged overdrinking.

Perhaps the best advice is for athletes to reconnect with what it really feels like to be truly thirsty. A long walk, cycle or run of 2-3 hours in the heat while drinking little will soon remind athletes that thirst is a remarkably powerful sensation. So powerful in fact that after an hour or two of exercising in the heat without drinking, the overpowering desire becomes that of stopping exercise and finding water. Anyone who has experienced the sensation of real thirst is quite capable of judging when they are and are not thirsty.

But the point remains that athletes will be much less likely to over-drink if they are told to drink only in response to thirst and not in order to stay "ahead of thirst."

When I work with athletes, I like to help them get a feel for their typical sweat losses by monitoring changes in body weight over different sessions of training and competition. The concept of developing an individualized hydration plan based on such information is promoted by several recent sets of guidelines for athletes. Do you have a problem with such an idea?

To be facetious and to make my point, I would ask this question: Do you think that veterinarian sports nutritionists also develop individualized drinking plans for horses and greyhounds, or for cheetahs, African hunting dogs, and migrating zebras, all of whom need to be athletic to survive? Or do we simply allow those creatures to drink in response to their biological cues? And if all athletic mammals (other than

humans) have survived in far more demanding circumstances for millennia without individualized drinking plans, could not athletic humans also survive simply by following the biological cues that we share with all God's creatures?

On the other hand, I certainly do not have any problem with individualized drinking plans for individual athletes. But I suspect it is a luxury that cannot be afforded by the majority of the world's athletes who do not have access to the exceptional government-funded support programs run by yourself and your colleagues at the Australian Institute of Sport or similar institutions in other countries.

I also appreciate that much of the support we give to athletes has as much a psychological as a physiological benefit. Any athlete who is part of a support program that also provides a personalized drinking plan has to believe that he or she is a better athlete as a result of that support and that he or she enjoys an advantage over athletes who do not receive such support. So even if it has no physiological benefit, an individualized drinking plan will be of psychological value. My only concern would be to insure that we do not encourage athletes to drink more than they absolutely need in weight-bearing sports like running and cycling. My impression is that the world's best athletes in those sports drink relatively little and some will tell you that the weight-loss they incur as a result helps their performances. Unfortunately it is extremely difficult to design experiments to evaluate this theory since such studies would likely have to be conducted out-of-doors and this introduces a host of uncontrollable variables that would likely negate the value of the study.

Perhaps the point is that if individualized drinking plans are provided for athletes, then there should be some attempt to prove that those individualized programs do actually improve the athletes' performances more than do other drinking behaviors. It might be presumptuous to assume that individualized programs are necessarily better simply because they were prescribed by an expert. We need to remain objective in all that we do and not to assume that our advice is always the best, simply because it is "scientific."

You are best known for your passion for running (your book "Lore of Running" is considered the Bible for this sport). But do you think that some of the issues of running or triathlon— particularly distance and ultra-distance events—are being over-represented in the guidelines for fluid intake during sports/exercise? For example, it might make sense in a marathon to tell a runner not to overdrink or to only drink from the aid station if they are thirsty. In this circumstance, the runner can be pretty sure that if they make such a decision at one aid station, there will be another aid station within a reasonable distance which will provide them with another opportunity to revise their actions. However in other sports, opportunities to drink and access to fluid are limited or sporadic. If a soccer player knows that they will not be able to drink during the 45 minute halves of a game in hot weather, perhaps it makes sense for them to have a drink just before the start of the game even if they aren't thirsty. A literal reading of your fluid guidelines would say that the soccer player shouldn't do this—even if it makes them feel better or helps them to reduce the accrued dehydration.

Ideally, soccer players and all involved in team sports played in the heat, should have access to fluid every 15 to 20 minutes. The problem here is not the guideline that athletes should drink only in response to thirst. Rather the problem is that fluid

should be made available to soccer players whenever they are thirsty and would like to drink.

I am certain that soccer players who are thirsty will not perform as well when they are thirsty as when they are not. Thus to optimize the performance of soccer players, either fluid should be made more freely available during soccer matches or players will need to learn how to play hard even when thirsty.

But the general guideline that athletes should drink only when thirsty remains. On the other hand, I see no reason why players should not drink before a match even though they are not thirsty. Your reasons are quite valid. There must always be specific exceptions to a general rule.

Can I give you another example where your proposed fluid guidelines cater for marathon runners (and perhaps even a minority of marathon runners) at the expense of the greater number of other situations of sport that are practiced around the world every day. Recently I did some fluid balance monitoring of elite cricket players, and I took along a freshly prepared education sheet on "fluid facts for cricket" which I planned to hand out in conjunction with the individual results. In good faith, I wrote a statement in bold at the bottom of the sheet, which I had intended to make a generic statement on all our fluid information for athletes: "You should not drink more than you sweat during exercise, so that you gain weight over the session." I agree this can be a concern in marathon runners, especially if they have been hydrating over the days leading up to the race and are already overhydrated when they take the starting line. But when these cricket players came to their morning training session—a 2.5 hour session undertaken in hot weather—we found that nearly half of the group was dehydrated (based on the specific gravity of their urine). Many had trained hard or played in a match the previous day. There are several other reports in the literature that show that many team athletes in daily training carry dehydration from one session to the next. In my cricket situation, one player who reported with a very high urinary specific gravity did a skill-based session and was found to have quite a modest sweat rate. His fluid intake over the session was also quite modest but was slightly higher than sweat rates, so that he gained about half a kilogram over the session. Although my handout strongly criticized what had just happened, in retrospect, it was probably a sensible strategy that helped him to maintain his fluid balance from day to day. So while we need to safeguard the health of a subgroup of athletes—the slow runners at the back of a marathon—do you think that we have forgotten about the needs or scenarios faced by the majority of sportspeople?

Human physiology is not specific exclusively to one group of athletes. Either thirst is the biological control that all creatures in the known Universe evolved optimally to regulate their body water content, or it is not.

What we now know is that drinking "as much as tolerable" is the worst possible advice that can be given to anyone involved in exercise that lasts more than about 4 hours (and not just slow marathon runners). For the reality is that once the exercise lasts more than about 4 to 6 hours the exercise intensity becomes sufficiently low that it becomes possible to drink too much. I have personally treated a semi-conscious athlete who developed hyponatremic encephalopathy at the 1998 Hawaiian Ironman Triathlon even though he finished in just over 10 hours, a fast

time by any measure. Despite his fast finishing time, he managed to over-hydrate himself by at least 4 to 5 kg (judging from the amount of urine he passed in the first 5 hours of his recovery). When asked why he had drunk so much, he naturally answered that this was what he had been told to do. Even when he began to vomit clear fluid during the cycle, he assumed that this was because he was "dehydrated" and so in need of more, not less fluid. Interestingly, one of the favorites in that race reportedly coughed up blood-stained sputum during the run, almost certainly indicating that he had developed fluid on the lungs (pulmonary edema) also as a consequence of over-drinking. Thus the advice to drink only according to thirst is crucial and may even be life-saving for anyone involved in more prolonged exercise. Such exercise includes ultra-distance running events, the Ironman Triathlon, 100 mile cycling races, and adventure races.

But your completely valid question is whether athletes involved in exercise of shorter duration and higher intensity might be at a disadvantage if they drink only according to thirst. The natural assumption is that this must be so since that is exactly what the drinking guidelines of many influential organizations tell us as do the advertisements sponsored by the sports drink industry. To answer this question, I reviewed all the published studies in which exercise performance was measured in well controlled trials in which athletes drank either according to their thirst ("ad libitum") or according to a drinking schedule that insured they drank more, usually "to replace all the fluid lost as sweat during exercise." Some studies also included a trial in which athletes drank less than "ad libitum."

The conclusions were absolutely clear—when athletes drank less than "ad libitum" they were likely to under-perform compared to "ad libitum" drinking (2). But there was no study in which drinking more than "ad libitum" improved performance more than the "ad libitum" condition. Thus if we are to be entirely evidence-based in the advice we give athletes, at this moment, we have to say that drinking "ad libitum" produces the optimum performance. Of course I do not expect this conclusion to be accepted overnight since it must overcome at least 20 years of an opposite message.

With regard to your specific example of the cricketers, we need to remember that a high urine specific gravity indicates that the body is conserving water. To show that an athlete with a high urine specific gravity is "dehydrated" requires that his total body water content also be measured. Unfortunately this is seldom done; rather levels of dehydration in athletes are measured on the basis of weight changes during exercise. But all the weight lost during exercise is not water and we do not know exactly how much of the water lost needs to be replaced to prevent any physiological consequences of such "dehydration." In addition, exercise on repeated days produces water conservation by the kidneys. Thus a cricketer with dark urine on the day after a hard session the previous day might actually have increased his total body water content as a result of the activation of these water-conserving mechanisms, principally the secretion of anti-diuretic hormone (ADH).

The persistence of an increased ADH secretion would also explain why the other cricketer gained weight despite a modest fluid intake. Of course it should never happen that athletes gain weight during exercise even if they drink more than they sweat; the kidneys should excrete the excess. But if blood ADH concentrations are

increased, this will not occur and the fluid will be retained. We have proposed that athletes who over-drink during exercise retain fluid because they are also suffering from the condition of inappropriate ADH secretion (SIADH) (4).

One concept behind drinking to thirst is that it should keep athletes from developing severe levels of dehydration that might be of concern to health. But do you think there is a gap between what prevents harm and what might enhance performance? You frequently show data that the top athletes in a race are the most dehydrated—and indeed it is very hard for an athlete doing high-intensity exercise to match a high sweat rate with the practicalities of drinking on the run. But do you think there is a place for some athletes to do a bit better than their current practices—to drink so that they are 2% dehydrated rather than 3% dehydrated over an event? Or to refuel with the carbohydrate that goes along with the sports drink? It's true that most research on fluid and carbohydrate replacement during exercise is lab-based. And not all studies report performance benefits (at least statistically significant outcomes). But it would seem that of all the nutrients or supplements that have been tested for performance enhancement, fluid and carbohydrate replacement have the most scientific support. Do you think that your guidelines discourage an athlete from being proactive in experimenting with fluid and carbohydrate replacement during exercise to see if there is a performance benefit?

I have argued earlier that the current evidence is that drinking "ad libitum" optimizes performance (2). Thus my conclusion is that it is not the level of dehydration that impairs exercise performance but rather whether or not the athlete is also thirsty. Thus the performance of an athlete who loses 8% of her body weight during an Ironman might not be impaired if she drinks enough so that she does not become thirsty. In contrast, an athlete who lost only 2% of his body weight might be impaired if he was also thirsty at the degree of weight loss.

Recently, we have presented evidence that the remarkable range of weight losses one measures in endurance athletes (from a weight loss of up to 11% to a weight gain of up to 6%) may be influenced by genetic factors determining how much different athletes chose to drink during exercise (5). If this is correct, then different athletes might perform optimally across a very wide range of dehydration levels.

Finally, another controversial theory! There is very good evidence that sweating provided our early human ancestors with the ability to run long distances in the heat and so to capture non-sweating antelope unable to control their core temperatures when chased by humans for 4 or more hours in extreme heat (> 40 °C) (3). In these hunts, humans would have had little if any opportunity to drink. Thus the most successful hunters would be those best able to "outrun" their thirst because they develop the least thirst during such hunts (and so were less tempted to conclude the hunt prematurely in order to search for water). If the extent to which we develop thirst is indeed genetically determined, then evolution would select out the best hunters (the forerunners of modern marathon runners) as those who developed the least thirst during exercise despite high levels of dehydration. If it is the symptoms of thirst, not the level of dehydration, that impair athletic performance, then these thirst-resistant hunters would be the most successful. In our modern culture, this would mean that the best endurance athletes are also those who drink the least

during exercise because they do not become thirsty and who therefore finish races with the highest levels of dehydration (6, 7).

I agree that the sole advantage of drinking more during exercise is that the intake of carbohydrate will be increased. But this can be easily remedied by insuring that athletes also eat an adequate amount of carbohydrate during exercise.

You have been very critical of sports drink companies for sponsoring research and accuse them of subverting the work or opinions of many sports scientists. Let's take the opposite view. Many supplement companies make thousands of dollars promoting products with extraordinary claims that are not supported by any science-based evidence. Don't such companies have a moral (if not legal) responsibility to invest in research to make sure that these claims are substantiated? Or to reinvest some of their profits to improve the knowledge that is available to the consumers who support their product? It makes me mad that some companies don't do that. Isn't it possible for sports scientists working in universities or institutes to do independent research funded by sports drink companies or other commercial entities—especially if they set up contracts that maintain their independence and their commitment to publishing their data? Your own laboratory at the University of Cape Town has a long history of doing research that has been funded by commercial interests, including supplement and sports drink companies. Clearly, you have been able to be ethical and independent in undertaking this research, while at the same time producing data that has greatly enhanced sports science knowledge. On what basis do you think that other researchers aren't working in the same way? Is there a better model?

What all scientists need to know is that there is only one lawful reason why publicly-listed companies in most countries can legally fund research. And that is to increase the wealth of the company's shareholders. That is the law. So any apparently philanthropic actions of publicly-listed companies, for example, the funding of research to determine what athletes should drink during exercise or what supplements they should take in training, are only legal if they increase the wealth of the shareholders of the sponsoring company. That reality stems from the case of Henry Ford versus the Dodge brothers heard in the Michigan Supreme Court in 1916. The point then is that no publicly-listed company can fund research on legal, moral, or ethical grounds unless that research can be shown to increase the sale of the product that is being researched. Increasing human knowledge does not enter the equation unless such knowledge can be turned into profit through increased product sales. Of course, no company funding research really wants their funded scientists (or the general public) to understand this troubling reality.

So the challenge for scientists like myself who work with industry is to understand that reality and to undertake ethical research that advances human knowledge while also fulfilling, in ethically correct ways, the requirement of the funding company. It is an uncomfortable balancing act in which only those scientists who are unscrupulously honest will retain their credibility. The slightest hint of weakness or dishonesty will be exploited by the funding company if that weakness can be turned into increased product sales.

The fundamental conflict in this relationship is between the scientist's need to undertake studies that advance human knowledge and to acknowledge *all* (and not

a convenient section) of the valid scientific information that has accumulated in the literature, and the sponsoring companies exclusive interest only in the information that will sell their products. And the absolute requirement of the sponsoring company that any contrary evidence that might affect their profitability, must be ruthlessly suppressed.

My criticism of what has happened in our discipline in the past 20 years is that a singular truth became the dominating doctrine even though there was a body of published evidence that questioned that theory. The dominating doctrine is that dehydration during exercise is so dangerous that all athletes must drink "as much as tolerable" to insure their health and to optimize their performance. This doctrine clearly encourages the over-use of sports drinks. When I started to question the basis for this new dogma and to undertake studies to evaluate it, I soon discovered that I quickly became a pariah in certain circles. All of a sudden I learned that I was not welcome at some conferences. This was a minor inconvenience. But far more worrying was the discovery that any of our papers that challenged this prevailing doctrine were essentially un-publishable in certain quality scientific journals in the US. Not in my prejudiced view because the studies were poorly conducted (all have been subsequently published in European or Canadian journals) but apparently because they came up with the "wrong" answers which challenged the dogma. Not for a moment do I believe that this was a carefully coordinated campaign of censorship conducted by a cohort of controlled and compliant scientists. I just think that the dogma had been allowed to become so ingrained that no one thought it could possibly be wrong. And so they were unwilling to question it.

In time, I discovered what Al Gore has exposed in his recent film—*An Inconvenient Truth*—that science can be subverted, sometimes willingly but perhaps most times unwittingly, to commercial interests by groups known as lobbyists and contrarians. These are scientists and others who work for an industry in the guise that they are presenting the "truth" whereas their real function is to prevent a real and inconvenient truth from being exposed to a gullible public which is being skillfully manipulated.

Contrarians, then, are those scientists who forgo their integrity and who present only one side of a distorted argument for reasons that go beyond their love of science and honesty. An important additional function of contrarians is to undermine the credibility, both among scientists and the general public, of any other scientists who attempt to expose the inconvenient truth.

To protect themselves and the public, scientists must remain true to what Nobel Laureate and acknowledged genius Richard Feynman described as our function: "*The only way to have real success in science is to describe the evidence very carefully without regard to the way you feel it should be. If you have a theory, you must try to explain what's good about it and what's bad about it equally. In science you learn a sort of standard integrity and honesty.*"

Provided scientists do that and do not become contrarian marionettes, manipulated for the exclusive commercial interests of the industry that funds their research, they will be fulfilling their scientific mandate and advancing human knowledge in an ethical way. As soon as I see the publication in our leading journals of more papers like that of Byrne et al. (1) which provide strong evidence to question the

prevailing dogma, the more certain I become that we are back on the right track. But we must remain eternally vigilant.

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