



AIS SPORTS SUPPLEMENT FRAMEWORK

GLYCEROL (GLYCERINE OR GLYCERIN)

What is it?

The oral ingestion of glycerol can be used to facilitate better retention of ingested fluids, which may be of benefit to athletes in sports where hydration status may be compromised due to prolonged and/ or intense exercise in thermally challenging environments and/ or when fluid access may be restricted.¹ Consumed simultaneously with a substantial volume of fluid, glycerol contributes to the osmotic pressure of body fluids and causes a temporary retention of fluid and expansion of body fluid compartments beyond normal fluctuations.^{2,3}

What does it look like?

- > Glycerol is a 3-carbon sugar alcohol that forms the backbone of triglycerides. It is stored in most human tissues and is released following lipolysis.
- > Glycerol is present in foods as a component of dietary fats derived from plants (e.g., soybeans) or animals (e.g., tallow). It is safe for human consumption.
- > Glycerol (Labelled as E422) is added to manufactured foods and drinks as an emulsifier, humectant, sweetener, low-energy filler or thickening agent, and preservative.
- > Glycerol is also used in the pharmaceutical industry to make soaps, toothpaste, cough syrups, creams and lotions.
- > Pure glycerol exists as a clear and very viscous non-hazardous liquid that is highly soluble in water.

How and when do I use it?

1. Pre-exercise hyperhydration

Pre-exercise hyperhydration is a state of elevated body water induced acutely prior to exercise by means of fluid ingestion with or without water-binding agents, such as Glycerol⁴

Glycerol-induced hyperhydration may be used to increase the athlete's capacity to tolerate fluid loss and offset (i.e., delay, prevent or attenuate) the deleterious effects of dehydration (e.g., fluid loss >2% BM) that can occur during exercise⁵. This strategy may be beneficial in a range of challenging situations that commonly arise in sport, such as:

- > When preparing for competition in which high fluid losses are anticipated through prolonged exposure to hot environments or when it is not possible for fluid intake to match sweat losses.
- > For athletes competing in sports where fluid consumption is impractical, such as during the swim-leg of an Ironman (World Triathlon Corporation) Triathlon race or during tournament-style of play in team sports, where matches are played in close succession over a day and there is limited time between matches to replace fluid loss.
- > When competition regulations limit an athletes access to fluids, for example tennis or football (soccer) match play.
- > Avoiding the need to drink during competition for example, maintaining a streamline position in a cycling time trial or avoiding an adjustment in the race line during a marathon such that the onset of the fluid intake is postponed.
- > When an athlete's voluntary fluid intake is reduced because of gastrointestinal distress or a reduced drive to drink.

The benefits associated with pre-exercise hyperhydration can be put into perspective when the consequences of dehydration (i.e., increase in body core temperature and thermal strain) during exercise can negate the physiological advantages resulting from increased fitness and heat acclimatization.⁶

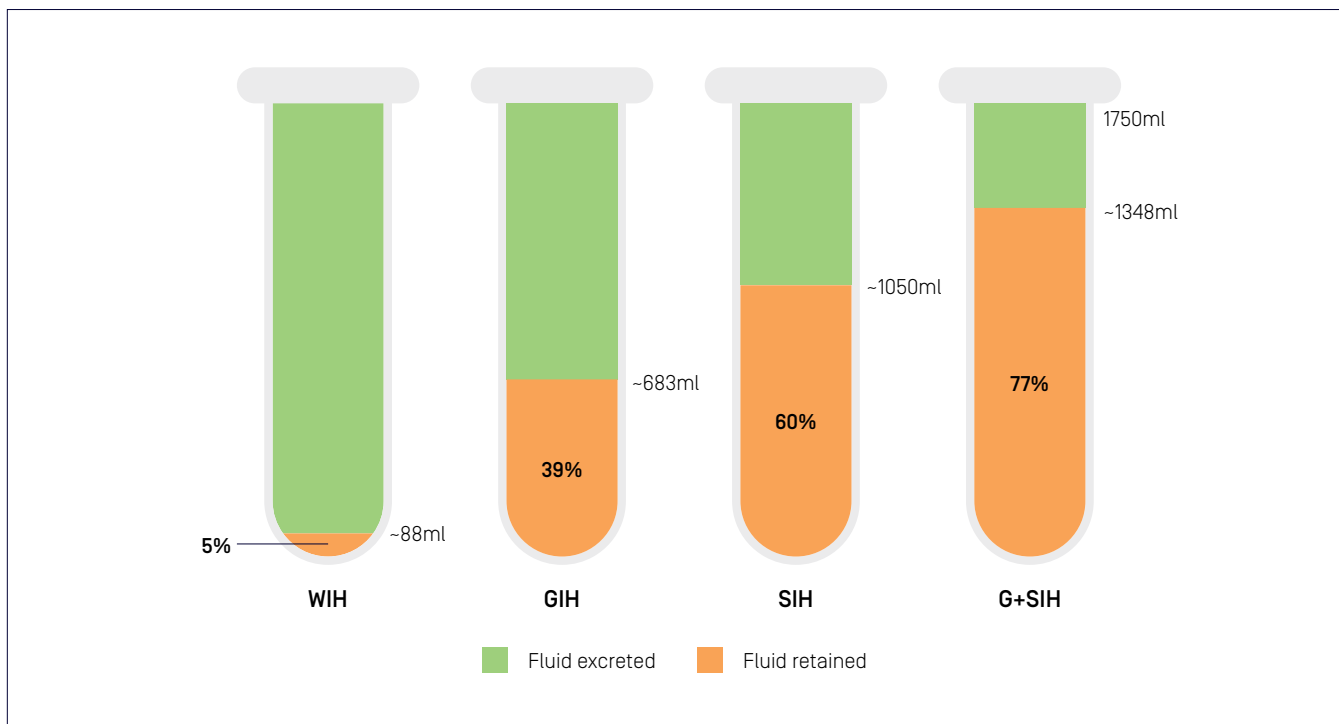
How is pre-exercise hyperhydration achieved?

Compared to hydrating with water, adding effective osmotic agents such as glycerol (and sodium; for more information, refer to 'Electrolytes') to a hydration solution will lower urine production and thus increase fluid retention². Accrued fluid retention with glycerol is possible through Glycerol's direct effect on reabsorbing fluid through the kidneys.⁷ Specifically, glycerol is reabsorbed by the kidney tubules, increasing the concentration gradient of the renal medulla, thereby water reabsorption in the nephron is enhanced.⁸



Since glycerol and sodium enhance fluid retention through different physiological mechanisms, sodium can also be added to glycerol hyperhydration solution because their combination can be more effective than either osmolyte alone. The following diagram illustrates the fluid retention achieved through three common hyperhydration strategies adapted from previous work conducted.^{2,3}

Figure 1. Comparative effects of different hyperhydration solutions on fluid retention. WIH – Water-induced hyperhydration, GIH – Glycerol-induced hyperhydration, SIH – Sodium-induced hyperhydration, G+SIH – Glycerol + Sodium-induced hyperhydration.



How and when do I hyperhydrate with glycerol?

Effective protocols of Glycerol-induced hyperhydration include the addition of 1.2 – 1.4 g/kg body mass Glycerol in ~25 ml/kg body mass fluid in the 90 – 180 min prior to exercise.¹ For example, a 75 kg athlete would weigh out 90 – 105 g glycerol on a set of calibrated kitchen scales and add their fluid of choice (i.e., 1875g water, cordial or sports drink).

As an alternative hyperhydration strategy, the addition of 3.0 g/L sodium, with or without glycerol, can be added to a hydration solution.³ To maintain palatability, an electrolyte supplement may be appropriate

What to expect?

- > When ingested orally, glycerol is rapidly absorbed and distributed throughout the body's fluid compartments, until it is gradually excreted over the next 24 – 48 h
- > In terms of the timing with other pre-event activities (e.g., warm up, marshalling duties, final preparations), peak urine production is likely to occur 60 – 80 min after ingestion
- > Greater fluid retention for up to 4 h after ingestion
- > Reduced urinary volume that is more concentrated
- > Compared to other hyperhydration strategies, the additional of glycerol to a solution is well tolerated with low abdominal discomfort
- > When combining glycerol and sodium-induced hydration strategies, you should expect to see lower urine production and greater fluid retention compared with glycerol-induced hyperhydration on its own
- > When compared to pre-exercise euhydration, pre-exercise hyperhydration has been shown to reduce dehydration-induced increases in heart rate and heat storage

2. Post-exercise hydration

Post-exercise rehydration strategies should aim to correct fluid and electrolyte losses accumulated during an event to enhance recovery and subsequent performance in training and/or competitions held over consecutive days. Under circumstances that limit time or prevent the consumption of meals or snacks that facilitates complete fluid balance restoration, glycerol may be used and offers the following benefits:

- > reduced diuresis associated with rehydration. In the case of rehydrating after exercise performed late in the day, glycerol-induced rehydration can reduce overnight diuresis to avoid interruptions to the athlete's sleep patterns
- > aggressive rehydration after weigh-in where weight-making practices (e.g., dehydration) have been implemented to achieve a target weight in weight-division sports

How and when do I hydrate with glycerol after exercise

The volume required to restore fluid balance will depend on the net deficit from sweat loss during the previous exercise bout. As a general guide, it may be necessary to drink up to 150% of weight loss.⁴

Add 1.0 g/kg body mass of glycerol to each 1.5 L fluid consumed.⁹

How do I source it?

Glycerol can be purchased in Australia from supermarkets, pharmacies, and chemists under the name of glycerine. The cost is less than \$AUD10 for 200 ml.

It should be noted that the description on the bottle can cause confusion, as it is listed for use as an emollient to soften roughened skin. Glycerol is safe to ingest according to the recommendations provided herein.

Is it ergogenic?

The ergogenic nature of glycerol has been investigated according to its effect on fluid retention, which has been shown to positively influence thermoregulatory function, cardiovascular responses and, hence, athletic performance.

Research on impact of glycerol on thermoregulation and performance have provided mixed results but some studies, including trials conducted at the AIS, have shown benefits to performance of moderate-high intensity exercise performed in the heat.

A meta-analysis concluded that the use of glycerol-induced hyperhydration in hot conditions provided a small [3% power output, effect size 0.35] but worthwhile enhancement to prolonged exercise performance above hyperhydration with water.

Glycerol is a permitted substance

Glycerol was formally removed from the World Anti-Doping Agency (WADA) Prohibited List on 1st January 2018. Glycerol is, therefore, currently a permitted substance for use in high-performance sport.

Are there any concerns or considerations?

Pre-exercise hyperhydration strategies involving glycerol supplementation need to be practiced in determining their effectiveness for individuals under real-life sorting scenarios. As such, the effectiveness of glycerol hyperhydration or rehydration strategies may depend upon the environmental conditions and exercise situations.

When used in accordance with the recommended ingestion protocols, glycerol is very safe with a very low prevalence of side-effects, making it relatively safe to use. However, the following concerns and considerations should be considered.

Concerns

- > Gastrointestinal discomfort, which can, in turn, impair athletic performance
- > The gain in body mass associated with more fluid being retained may create a performance impairment
- > Nausea
- > Headaches
- > Laxative effect



Considerations

- > Over and under drinking of fluids can be harmful so athletes should seek the advice of an Accredited Sports Dietitian for individual guidance around the use of glycerol.
- > If an athlete is unable to tolerate such large volumes of fluid required to induce pre-exercise hyperhydration then a smaller volume of the same concentration of glycerol solution may be ingested closer to the commencement of exercise.⁹
- > There is no physiological (i.e., cardiovascular and thermoregulatory) advantage in performing pre-exercise hyperhydration for athletes who can commence exercise in a euhydrated (i.e., normal state of body water content) state when the ability to drink prevents a fluid deficit within 2% of body mass.¹¹ As this is typically not the case during ultra-endurance races, glycerol-induced hyperhydration is not recommended prior to such activities and may cause prolonged fluid overloading.
- > Most laboratory-based hyperhydration studies have compared and quantified the fluid retention achieved through the ingestion large boluses of flavoured water, with and without the addition of glycerol (and sodium). While water services a scientific study as a good 'control beverage', a carbohydrate-electrolyte drink may provide a better hydration potential than water alone.¹²

How else can glycerol be used effectively?

Optimising an ice-slurry beverage

Improved exercise performance with glycerol may not simply be explained by an attenuated body fluid deficit but may be the result of a reduction in deep body core temperature.

The use of internal pre-event cooling strategies, such as ice-slurries and cold beverages have been shown to increase the athlete's capacity to store environmental and metabolic heat gained during exercise.

Glycerol's ability to hydrogen-bond with water means that when a glycerol:water mixture is cooled it lowers the freezing point of the solution before ice starts to form, acting as an 'anti-freeze'. The addition of glycerol (or other solutes, such as carbohydrate and/or sodium) to a hydration solution allows it to be served at sub-zero temperatures and improves its consistency so frozen beverage can be readily ingested using a straw.¹ A practical limitation may involve the discomfort associated with subsequent brain freeze (i.e., sphenopalatine ganglioneuralgia).

Considerations

- > Since the timing of hyperhydration (90-180 min pre-exercise) and pre-cooling (30-60 min pre-exercise) strategies are implemented at different times prior to the start of exercise, the dose of glycerol can be split between the beverages but favouring the timing of delivery of the hyperhydration beverage. For instance, withhold 0.2 - 0.4 g/kg BM glycerol from the glycerol-based hyperhydration to add to the slushie.
- > Explicit ingredient labelling is required if adding glycerol to an ice-slurry machine so other users are aware of the contents

Where can I find more information?

Sports Dietitians Australia

www.sportsdietitians.com.au/sda-blog/media-release-sda-heat-position-statement

Supplement safety information

www.sportintegrity.gov.au/what-we-do/anti-doping/supplements-sport

References

1. McCubbin A, Allanson B, Caldwell J, et al. (2020). Sports Dietitians Australia position statement: Nutrition for exercise in hot environments. *Int J Sport Nutr Exerc Metab*, 31, 1-16.
2. Savoie FA, Dion T, Asselin A, Goulet ED. (2015). Sodium-induced hyperhydration decreases urine output and improves fluid balance compared with glycerol- and water-induced hyperhydration. *Appl Physiol Nutr Metab*, 40(1), 51-8.
3. Goulet E, De La Flore A, Savoie F, Gosselin J. (2018). Salt + glycerol-induced hyperhydration enhances fluid retention more than salt- or glycerol-induced hyperhydration. *Int J Sport Nutr Exerc Metab*, 28(3), 246-252.
4. Sawka M, Burke L, Eichner E, et al. (2007). American College of Sports Medicine position stand. Exercise and fluid replacement. *Med Sci Sports Exerc*, 39(2), 377-90.
5. Goulet E, Aubertin-Leheudre M, Plante G, Dionne I. (2007). A meta-analysis of the effects of glycerol-induced hyperhydration on fluid retention and endurance performance. *Int J Sport Nutr Exerc Metab*, 17(4), 391-410.
6. Casa D, Armstrong L, Hillman S, et al. (2000). National athletic trainers' association position statement: fluid replacement for athletes. *J Athl Train*, 35(2), 212-24.
7. Greenleaf, J.E. (1992). Problem: thirst, drinking behavior, and involuntary dehydration. *Med. Sci. Sports Exerc*. 24(6), 645-656.



8. Robergs RA, Griffin SE. (1998). Glycerol: Biochemistry, pharmacokinetics and clinical and practical applications. *Sports Med*, 26(3), 145-67.
9. van Rosendal S, Osborne M, Fasset R, Coombes J. (2010). Guidelines for glycerol use in hyperhydration and rehydration associated with exercise. *Sports Med*, 40(2), 113-29.
10. Thomas D, Erdman K, Burke L. (2016). Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. *Journal of the Academy of Nutrition and Dietetics*, 116(3), 501-528.
11. Latzka W, Sawka M, Montain S, et al. (1997). Hyperhydration: thermoregulatory effects during compensable exercise-heat stress. *J Appl Physiol*, 83(3), 860-6.
12. Goulet E. (2009). Review of the effects of glycerol-containing hyperhydration solutions on gastric emptying and intestinal absorption in humans and in rats. *Int J Sport Nutr Exerc Metab*, 19(5), 547-60.

Further Reading

1. Burke L, Stear S, Lobb A, et al. (2011). A-Z of nutritional supplements: dietary supplements, sports nutrition foods and ergogenic aids for health and performance—Part 19. *British Journal of Sports Medicine*, 45, 456-58.
2. Goulet EDB. (2008). Pre-Exercise Hyperhydration: Comments on the 2007 ACSM Position Stand on Exercise and Fluid Replacement. *JEPonline*, 11(2), 64-74.

The Australian Institute of Sport (AIS) Supplement Framework is an initiative of the Australian High Performance Sport System. The AIS acknowledges the support of members of the National Institute Network (NIN) and National Sporting Organisations (NSO) and their staff in delivering content expertise. This information is intended to help athletes, coaches and scientists make evidence-based decisions about the use of supplements and sports foods. Before engaging in supplement use, we recommend that each individual refer to the specific supplement policies of their sporting organisation, sports institute or parent body, and seek appropriate professional advice from an accredited sports dietitian (www.sportsdietitians.com.au).

Athletes should be aware that the use of supplements may have doping implications. Athletes are reminded that they are responsible for all substances that enter their body under the 'strict liability' rules of the World Anti-Doping Code. Some supplements are riskier than others. The Sport Integrity Australia (SIA) app is a useful resource to help mitigate the risk of inadvertent doping by helping to identify supplements that have been batch-tested. The SIA App provides a list of more than 11,000 batch-tested products. We recommend that all athletes consult the educational resources of SIA regarding the risks associated with supplements and sports foods. While batch-tested products have the lowest risk of a product containing prohibited substances, they cannot offer you a guarantee that they are not contaminated (www.sportintegrity.gov.au/what-we-do/supplements-sport).

© Australian Institute of Sport
Last updated March 2021

