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| Question 1: |
| **Should Carbohydrate-electrolyte solutions vs. water be used for rehydration after exertion-related dehydration?** |
| **Population:** | Rehydration after exertion-related dehydration |
| **Intervention:** | Carbohydrate-electrolyte solutions |
| **Comparison:** | Water |
| **Main outcomes:** | Cumulative urine output; Net fluid balance; Plasma volume changes; Haematocrit; Heart rate; Serum osmolality; Plasma osmolality; Serum sodium concentration; Thirst; Fullness; Nausea; Stomachache; Stomach upset; Bloating; Abdominal discomfort  |
| **Setting:** | Out-of-hospital setting, experimental cross-over design |
| **Perspective:** | Guideline writers on behalf of individuals |
| **Background:** | Strenuous exercise leads to increased heat production and sweating, which in turn can lead to loss of fluid and electrolytes. If not compensated, thermoregulatory processes will be disrupted, which can have detrimental effects on physiological function and exercise performance. Restoration of fluid balance after exercise can help to minimize this. The electrolyte balance of the ingested fluid plays a key role in the rehydration process. |
| **Conflict of interests:** | None reported |

# Assessment

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| ProblemIs the problem a priority? |
| Judgement | Research evidence | Additional considerations |
| ○ No○ Probably no● Probably yes○ Yes○ Varies○ Don't know | Human body water accounts for 50-70% of the total body mass but, despite this abundance, it is regulated within narrow ranges. During prolonged exercise, sweat losses generally exceed fluid intake and even low levels of dehydration (about 2% of the body mass) already impair thermoregulation (Kenefick 2018, 1) and cardiovascular strain (Crandall 2010, 407; Adams 2014, 686). When these dysfunctions are allowed to progress, they can lead to impaired physical and cognitive performance (Masento 2014, 1841; Savoie 2015, 1207), syncope due to hypotension and, finally, heat illness that can be fatal (Carter 2005, 1338). In such situations, it is of utmost importance to promote post-exercise drinking to restore fluid balance. For rapid and complete rehydration, the drink volume and composition are key (Osterberg 2010, 245; James 2015, 521). Although the NATA states that up to 150% of the estimated fluid deficit needs to be consumed to effectively replace fluid losses after exercise over a short recovery period (less than 4 hours) (McDermott 2017, 877), there is no clear endorsement regarding the specific type of rehydrating fluid.  |  |
| Desirable EffectsHow substantial are the desirable anticipated effects? |
| Judgement | Research evidence | Additional considerations |
| ○ Trivial● Small○ Moderate○ Large○ Varies○ Don't know | 4-9% CE solution vs waterOne study showed a significant decrease in **cumulative urine output** from 4% CE solution compared with water (MD, -289 ml; 95% CI could not be calculated). In addition, 2 showed a significant decrease in cumulative urine output from 6% CE solution when compared with water (MD, -160 ml and MD, -465 ml; respectively; 95% CI could not be calculated). One study could not demonstrate a difference for cumulative urine output, when comparing 6% CE solution with water. Two showed a significant decrease of cumulative urine output when comparing 6.6% CE solution with water (MD, -241 ml and MD, -277 ml; respectively; 95% CI could not be calculated). In 5 studies a significant difference in cumulative urine output could not be demonstrated when comparing 6.5% CE, 6.9% CE, 7% CE, 8% CE or 8.75% CE solution with water.No significant differences could be demonstrated for net fluid balance, plasma volume change, hematocrit or heart rate when comparing 4-9% CE solutions with water.Low certainty evidence (downgraded for risk of bias and imprecision) from one study showed a significant increase in **serum sodium concentration** 1 h after completion of drinking 6.9% CE solution when compared with water (MD, 4 mmol/L; 95% CI could not be calculated). However, in two other studies of low certainty (downgraded for risk of bias and imprecision) a significant difference in serum sodium concentration 1h15 after completion of drinking 6% CE solution or 30 min after completion of drinking 8.75% CE solution could not be demonstrated when compared with water.Very low certainty evidence (downgraded for risk of bias, imprecision and strongly suspected publication bias) from two studies showed a significant increase in **serum osmolality** 1 h and 1h 15 after completion of drinking 6% CE solution when compared with water (MD, 5.9 mOsm/kg and 4.5 mOsm/kg; respectively; 95% CI could not be calculated). Three studies of low certainty (downgraded for risk of bias and imprecision) could not demonstrate a significant difference in serum osmolality 2 h after completion of drinking 6% CE solution, 1 h after completion of drinking 6.9% CE solution or 30 min after completion of drinking 8.75% CE solution when compared with water could not be demonstrated. No significant differences could be demonstrated for plasma osmolality when comparing 4-9% CE solutions with water. No significant differences could be demonstrated for patient satisfaction outcomes (thirst, stomach fullness, nausea, stomachache, abdominal discomfort, bloating) when comparing 4-9% CE solutions with water.0%-3.9% CE drinks vs water Two RCTs showed a significant decrease in **cumulative urine output** from 0% CE (NaCl) solution and 3.7% CE solution compared with water (MD, -416 ml; 95% CI -786 to -46; MD, -174.5 ml; 95% CI could not be calculated; respectively). However, in 3 other randomized studies a significant difference in cumulative urine volume, when comparing 2% CE, 3.2% CE or 3.9% CE with could not be demonstrated.No significant differences could be demonstrated for net fluid balance, hematocrit or hemoglobin, plasma volume or plasma volume change or heart rate when comparing 0-4% CE solutions with water. One non-RCT and one RCT showed a significant increase in **serum sodium concentration** 1 h after completion of drinking 1.83% CE solution or 3.7% CE solution when compared with water (MD, 3.4 mmol/L and MD, 2 mmol/L; respectively; 95% CI could not be calculated). However, in one other randomized study a significant difference in serum sodium concentration could not be demonstrated, when comparing 3.2% CE solution with water. One non-RCT and one RCT showed a significant increase in **serum osmolality** 1 h after completion of drinking 1.83% CE solution or 3.7% CE solution when compared with water (MD, 9.0 mOsm/kg and MD, 4 mOsm/kg respectively; 95% CI could not be calculated). In one randomized study a significant difference in serum osmolality, 1 h after completion of drinking 3.2% CE when compared with water, could not be demonstrated. Additionally, in 2 other randomized studies, a significant difference in plasma osmolality 1 h after completion of drinking 2% CE or 3.9% CE solution when compared with water could not be demonstrated. Furthermore, a significant difference in plasma osmolality 2 h after completion of drinking 2% CE or 3.9% CE solution when compared with water could also not be demonstrated.No significant differences could be demonstrated for patient satisfaction outcomes (thirst, stomach fullness, nausea, stomach upset) when comparing 4-9% CE solutions with water.  | When consuming a fixed volume of beverage, a reduced urine output indicates a better retention of the consumed beverage and, hence, stimulates the rehydration process.Exertion-related dehydration was characterized by an increase in directly measured serum/plasma osmolality and electrolyte concentrations because sweat is hypotonic relative to plasma (Hooper 2015, e008846). During rehydration, restoring and maintaining high levels of plasma and serum osmolality and electrolyte concentrations is desirable and avoids the stimulation of diuresis. A rapid fall in these outcome measures during rehydration will indeed stimulate urine output and increases the risk of developing (symptoms of) hyponatremia. |
| Undesirable EffectsHow substantial are the undesirable anticipated effects? |
| Judgement | Research evidence | Additional considerations |
| ○ Large○ Moderate○ Small● Trivial○ Varies○ Don't know | No undesirable effects were identified. |  |
| Certainty of evidenceWhat is the overall certainty of the evidence of effects? |
| Judgement | Research evidence | Additional considerations |
| ● Very low○ Low○ Moderate○ High○ No included studies | Downgraded due to serious risk of bias and imprecision due to small sample sizes and lack of data. In some studies, publication bias is strongly suspected.  | Bias was assessed per study and patient satisfaction outcomes were assessed separately, since for these outcomes, lack of blinding may influence the outcome assessment. In addition, we suspect that some study findings may be biased by industry funding and sponsorship |
| ValuesIs there important uncertainty about or variability in how much people value the main outcomes? |
| Judgement | Research evidence | Additional considerations |
| ○ Important uncertainty or variability○ Possibly important uncertainty or variability● Probably no important uncertainty or variability○ No important uncertainty or variability |  |  |
| Balance of effectsDoes the balance between desirable and undesirable effects favor the intervention or the comparison? |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison○ Probably favors the comparison○ Does not favor either the intervention or the comparison● Probably favors the intervention○ Favors the intervention○ Varies○ Don't know | No undesirable effects, some beneficial effects. |  |
| Resources requiredHow large are the resource requirements (costs)? |
| Judgement | Research evidence | Additional considerations |
| ○ Large costs● Moderate costs○ Negligible costs and savings○ Moderate savings○ Large savings○ Varies○ Don't know | Prices of sports drinks in Belgium: Gatorade: 1.83€ for 0.5LAcquarius: 1.60€ for 0.5 L | In general, CE drinks are more expensive than water, particularly tap water. |
| Certainty of evidence of required resourcesWhat is the certainty of the evidence of resource requirements (costs)? |
| Judgement | Research evidence | Additional considerations |
| ○ Very low○ Low○ Moderate○ High● No included studies |  |  |
| Cost effectivenessDoes the cost-effectiveness of the intervention favor the intervention or the comparison? |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison○ Probably favors the comparison● Does not favor either the intervention or the comparison○ Probably favors the intervention○ Favors the intervention○ Varies○ No included studies |  |  |
| EquityWhat would be the impact on health equity? |
| Judgement | Research evidence | Additional considerations |
| ○ Reduced● Probably reduced○ Probably no impact○ Probably increased○ Increased○ Varies○ Don't know |  | The higher cost of CE solutions compared with water will decrease the equity. Particularly in places where tap water is potable.  |
| AcceptabilityIs the intervention acceptable to key stakeholders? |
| Judgement | Research evidence | Additional considerations |
| ○ No○ Probably no● Probably yes○ Yes○ Varies○ Don't know |  | CE drinks are probably very acceptable amongst people performing exercise. On the other hand, the higher cost and requirement to store bottles could make it less acceptable than water, especially in areas where tap water is drinkable. CE drinks may be less feasible than water, primarily due to cost, but it would also require storage of bottles. Particularly in areas where tap water is drinkable. |
| FeasibilityIs the intervention feasible to implement? |
| Judgement | Research evidence | Additional considerations |
| ○ No○ Probably no● Probably yes○ Yes○ Varies○ Don't know |  | CE drinks may be less feasible than water, primarily due to cost, but it would also require storage of bottles. Particularly in areas where tap water is drinkable. |

# Summary of judgements

|  | **Judgement** |
| --- | --- |
| **Problem** | No | Probably no | **Probably yes** | Yes |  | Varies | Don't know |
| **Desirable Effects** | Trivial | **Small** | Moderate | Large |  | Varies | Don't know |
| **Undesirable Effects** | Large | Moderate | Small | **Trivial** |  | Varies | Don't know |
| **Certainty of evidence** | **Very low** | Low | Moderate | High |  |  | No included studies |
| **Values** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability |  |  |  |
| **Balance of effects** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | Don't know |
| **Resources required** | Large costs | **Moderate costs** | Negligible costs and savings | Moderate savings | Large savings | Varies | Don't know |
| **Certainty of evidence of required resources** | Very low | Low | Moderate | High |  |  | **No included studies** |
| **Cost effectiveness** | Favors the comparison | Probably favors the comparison | **Does not favor either the intervention or the comparison** | Probably favors the intervention | Favors the intervention | Varies | No included studies |
| **Equity** | Reduced | **Probably reduced** | Probably no impact | Probably increased | Increased | Varies | Don't know |
| **Acceptability** | No | Probably no | **Probably yes** | Yes |  | Varies | Don't know |
| **Feasibility** | No | Probably no | **Probably yes** | Yes |  | Varies | Don't know |

# Type of recommendation

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| --- | --- | --- | --- | --- |
| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | **Conditional recommendation for the intervention** | Strong recommendation for the intervention |
| ○  | ○  | ○  | **●**  | ○  |

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| Question 2: |
| **Should low-fat or skim milk vs. water be used for rehydration after exertion-related dehydration?** |
| **Population:** | Rehydration after exertion-related dehydration |
| **Intervention:** | Low-fat or skim milk |
| **Comparison:** | Water |
| **Main outcomes:** | Cumulative urine; Net fluid balance; Plasma osmolality; Thirst; Bloating |
| **Setting:** | Out-of-hospital setting, experimental cross-over design |
| **Perspective:** | Guideline developers on behalf of individuals |
| **Background:** | Strenuous exercise leads to increased heat production and sweating, which in turn can lead to loss of fluid and electrolytes. If not compensated, thermoregulatory processes will be disrupted, which can have detrimental effects on physiological function and exercise performance. Restoration of fluid balance after exercise can help to minimize this. The electrolyte balance of the ingested fluid plays a key role in the rehydration process. |
| **Conflict of interests:** | None reported |

# Assessment

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| ProblemIs the problem a priority? |
| Judgement | Research evidence | Additional considerations |
| ○ No○ Probably no● Probably yes○ Yes○ Varies○ Don't know | Human body water accounts for 50-70% of the total body mass but, despite this abundance, it is regulated within narrow ranges. During prolonged exercise, sweat losses generally exceed fluid intake and even low levels of dehydration (about 2% of the body mass) already impair thermoregulation (Kenefick 2018, 1) and cardiovascular strain (Crandall 2010, 407; Adams 2014, 686). When these dysfunctions are allowed to progress, they can lead to impaired physical and cognitive performance (Masento 2014, 1841; Savoie 2015, 1207), syncope due to hypotension and, finally, heat illness that can be fatal (Carter 2005, 1338). In such situations, it is of utmost importance to promote post-exercise drinking to restore fluid balance. For rapid and complete rehydration, the drink volume and composition are key (Osterberg 2010, 245; James 2015, 521). Although the NATA states that up to 150% of the estimated fluid deficit needs to be consumed to effectively replace fluid losses after exercise over a short recovery period (less than 4 hours) (McDermott 2017, 877), there is no clear endorsement regarding the specific type of rehydrating fluid.  |  |
| Desirable EffectsHow substantial are the desirable anticipated effects? |
| Judgement | Research evidence | Additional considerations |
| ○ Trivial● Small○ Moderate○ Large○ Varies○ Don't know | Very low certainty evidence (downgraded for risk of bias, imprecision and suspected publication bias) from 4 studies showed a significant decrease of **cumulative urine output** from skim or low-fat cow's milk compared with water (MD, -368 ml; MD, -635 ml; MD, -594 ml and MD, -175 ml; respectively; 95% CI could not be calculated; P<0.05). Very low certainty evidence (downgraded for risk of bias, imprecision and suspected publication bias) from 3 studies showed a significant increase in **net fluid balance** after 1 h (MD, 655 ml; MD, 368 ml and MD, 111 ml; respectively; 95% CI could not be calculated; P<0.05) and 2 h (MD, 675 ml; MD, 621 ml and MD, 179 ml; respectively; 95% CI could not be calculated; P<0.05) from skim milk when compared with water. In addition, very low certainty evidence from one study showed a significant increase in net fluid balance after 30 min to 1.5 h (MD, 0.26 L; 95% CI could not be calculated; P<0.05) or after 1.5 to 2.5 h (MD, 0.36 L; 95% CI could not be calculated; P<0.05) from low-fat cow's milk when compared with water. Very low certainty evidence (downgraded for risk of bias, imprecision and suspected publication bias) from one study showed a significant increase in **plasma osmolality** after 1.5 to 2.5 h from skim milk when compared with water (MD, 3 mOsm/kg; 95% CI could not be calculated; P<0.05). However, low certainty evidence (downgraded for risk of bias and imprecision due to limited sample size and lack of data) from another study could not demonstrate a significant difference for plasma osmolality from skim milk when compared with water after 1 h and 2. | When consuming a fixed volume of beverage, a reduced urine output indicates a better retention of the consumed beverage and, hence, stimulates the rehydration process.Restoration of the net fluid balance is beneficial and larger values indicate the sweat losses are replaced effectively.Exertion-related dehydration was characterized by an increase in directly measured serum/plasma osmolality and electrolyte concentrations because sweat is hypotonic relative to plasma (Hooper 2015, e008846). During rehydration, restoring and maintaining high levels of plasma and serum osmolality and electrolyte concentrations is desirable and avoids the stimulation of diuresis. A rapid fall in these outcome measures during rehydration will indeed stimulate urine output and increases the risk of developing (symptoms of) hyponatremia. |
| Undesirable EffectsHow substantial are the undesirable anticipated effects? |
| Judgement | Research evidence | Additional considerations |
| ○ Large○ Moderate● Small○ Trivial○ Varies○ Don't know | Very low certainty evidence (downgraded for risk of bias, imprecision and suspected publication bias) from one study showed significantly more **stomach fullness** immediately after drinking low-fat cow's milk (MD, 10 (30 min rehydration period) and MD, 34 (90 min rehydration period); 95% CI could not be calculated; P<0.05), 30 min after drinking milk (MD, 18 (90 min rehydration period); 95% CI could not be calculated; P<0.05) and 90 min after drinking milk (MD, 17 (30 min rehydration period) and MD, 11 (90 min rehydration period); 95% CI could not be calculated, P<0.05) when compared with water. Very low certainty evidence (downgraded for risk of bias, imprecision and suspected publication bias) from 2 other studies could not demonstrate a significant difference in stomach fullness immediately after drinking skim milk, when compared with water.Very low certainty evidence (downgraded for risk of bias, imprecision and strongly suspected publication bias) from one study showed significantly more bloating immediately after drinking low-fat cow's milk (MD, 9 (30 min rehydration period) and MD, 9 (90 min rehydration period); 95% CI could not be calculated; P<0.05), 30 min after drinking milk (MD, 14 (90 min rehydration period); 95% CI could not be calculated; P<0.05) and 90 min after drinking milk (MD, 10 (30 min rehydration period) and MD, 5 (90 min rehydration period); 95% CI could not be calculated, P<0.05) when compared with drinking water. Very low certainty evidence (downgraded for risk of bias, imprecision and strongly suspected publication bias) from one other study could not demonstrate a significant difference in bloating immediately after or 2 h after drinking skim milk, when compared with water. | Patient satisfaction outcomes (thirst, stomach fullness, bloating, nausea) were measured with a Visual Analogue Scale (VAS). Lower scores are beneficial when assessing patient satisfaction after drinking.For patients with lactose intolerance, the use of milk may induce diarrhea. This could hamper the effect of rehydration or even worsen the dehydration status, and becomes an important undesirable effect in this group of patients, |
| Certainty of evidenceWhat is the overall certainty of the evidence of effects? |
| Judgement | Research evidence | Additional considerations |
| ● Very low○ Low○ Moderate○ High○ No included studies | Downgraded due to serious risk of bias and imprecision due to small sample sizes and lack of data. In some studies, publication bias is strongly suspected.  | Bias was assessed per study and patient satisfaction outcomes were assessed separately, since for these outcomes, lack of blinding may influence the outcome assessment.  |
| ValuesIs there important uncertainty about or variability in how much people value the main outcomes? |
| Judgement | Research evidence | Additional considerations |
| ○ Important uncertainty or variability○ Possibly important uncertainty or variability● Probably no important uncertainty or variability○ No important uncertainty or variability |  |   |
| Balance of effectsDoes the balance between desirable and undesirable effects favor the intervention or the comparison? |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison○ Probably favors the comparison○ Does not favor either the intervention or the comparison○ Probably favors the intervention○ Favors the intervention● Varies○ Don't know | There are beneficial effects for rehydration, but there are some undesirable effects when looking at patient satisfaction outcomes | There may be beneficial effects for milk, but fullness and bloating will affect athletics and therefore, performance and may not be used.For patients with lactose intolerance, the undesirable effect of diarrhea may outweigh the desirable effect of rehydration. |
| Resources requiredHow large are the resource requirements (costs)? |
| Judgement | Research evidence | Additional considerations |
| ○ Large costs● Moderate costs○ Negligible costs and savings○ Moderate savings○ Large savings○ Varies○ Don't know |  | Milk is not very expensive but may have a higher cost than water.The cost of whole milk varies between 2.71 USD and 8.99 USD per gallon in the US depending on geography and milk type. <https://www.ams.usda.gov/sites/default/files/media/RetailMilkPrices.pdf> The equipment or resources for milk storage (e.g. refrigerator, ice bag, or insulation bag) may further increase the cost.From the logistics point of view, the limited period of use also increases the cost of milk. |
| Certainty of evidence of required resourcesWhat is the certainty of the evidence of resource requirements (costs)? |
| Judgement | Research evidence | Additional considerations |
| ○ Very low○ Low○ Moderate○ High● No included studies |  |  |
| Cost effectivenessDoes the cost-effectiveness of the intervention favor the intervention or the comparison? |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison● Probably favors the comparison○ Does not favor either the intervention or the comparison○ Probably favors the intervention○ Favors the intervention○ Varies○ No included studies |  | The monthly cost of water for a family of 4 is 115.50 USD per 150 gal or 0.77 USD per gallon.<https://www.circleofblue.org/2019/world/2019-price-of-water/>The cost of milk plus the storage equipment makes milk less cost-effective than water. |
| EquityWhat would be the impact on health equity? |
| Judgement | Research evidence | Additional considerations |
| ○ Reduced● Probably reduced○ Probably no impact○ Probably increased○ Increased○ Varies○ Don't know | Milk is often available and consumed, but this is not the case in all countries (<https://www.statista.com/statistics/272003/global-annual-consumption-of-milk-by-region/>) 65% or more of the total human population are lactose intolerant (Vuorisalo 2012, 163). In some regions, the prevalence of lactose intolerance is higher than in other regions, making milk a less suitable rehydration solution. (<https://milk.procon.org/lactose-intolerance-by-country/>).  | Equity is probably reduced because of the expense and potential refrigeration requirements. |
| AcceptabilityIs the intervention acceptable to key stakeholders? |
| Judgement | Research evidence | Additional considerations |
| ○ No○ Probably no○ Probably yes○ Yes● Varies○ Don't know | Depends on the perception of what is needed for rehydration. Most people will believe water is best for rehydration, and not think about milk (Saheen 2018, 1346).  | Milk may be less acceptable by people that do not use animal products.For patients with lactose intolerance, the undesirable effect of diarrhea may reduce the acceptability.  |
| FeasibilityIs the intervention feasible to implement? |
| Judgement | Research evidence | Additional considerations |
| ○ No○ Probably no○ Probably yes○ Yes● Varies○ Don't know |  | Milk generally requires refrigeration, which may not always be accessible. Skim milk may not always be available versus other milk fat concentrations. Improperly stored or spoiled milk may have significant adverse effect.Storage and taste will be issues affecting usage, particularly in organized sport. Milk is less feasible than water due to cost, refrigeration and reliance on animal product and potentially needing a specific milk fat concentration.  |

# Summary of judgements

|  | **Judgement** |
| --- | --- |
| **Problem** | No | Probably no | **Probably yes** | Yes |  | Varies | Don't know |
| **Desirable Effects** | Trivial | **Small** | Moderate | Large |  | Varies | Don't know |
| **Undesirable Effects** | Large | Moderate | **Small** | Trivial |  | Varies | Don't know |
| **Certainty of evidence** | **Very low** | Low | Moderate | High |  |  | No included studies |
| **Values** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability |  |  |  |
| **Balance of effects** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | **Varies** | Don't know |
| **Resources required** | Large costs | **Moderate costs** | Negligible costs and savings | Moderate savings | Large savings | Varies | Don't know |
| **Certainty of evidence of required resources** | Very low | Low | Moderate | High |  |  | **No included studies** |
| **Cost effectiveness** | Favors the comparison | **Probably favors the comparison** | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | No included studies |
| **Equity** | Reduced | **Probably reduced** | Probably no impact | Probably increased | Increased | Varies | Don't know |
| **Acceptability** | No | Probably no | Probably yes | Yes |  | **Varies** | Don't know |
| **Feasibility** | No | Probably no | Probably yes | Yes |  | **Varies** | Don't know |

# Type of recommendation

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| --- | --- | --- | --- | --- |
| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | **Conditional recommendation for the intervention** | Strong recommendation for the intervention |
| ○  | ○  | ○ | **●**  | ○  |

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| Question 3: |
| **Should coconut water (fresh or from concentrate) vs. water be used for rehydration after exertion-related dehydration?** |
| **Population:** | Rehydration after exertion-related dehydration |
| **Intervention:** | Coconut water (fresh or from concentrate) |
| **Comparison:** | Water |
| **Main outcomes:** | Cumulative urine output; Net fluid balance; Plasma volume change; Heart rate; Serum osmolality; Serum sodium concentration; Plasma osmolality; Thirst; Fullness; Nausea; Stomach ache; Stomach upset; Bloating  |
| **Setting:** | Out-of-hospital setting, experimental cross-over design |
| **Perspective:** | Guideline developers on behalf of individuals |
| **Background:** | Strenuous exercise leads to increased heat production and sweating, which in turn can lead to loss of fluid and electrolytes. If not compensated, thermoregulatory processes will be disrupted, which can have detrimental effects on physiological function and exercise performance. Restoration of fluid balance after exercise can help to minimize this. The electrolyte balance of the ingested fluid plays a key role in the rehydration process. |
| **Conflict of interests:** | None reported |

# Assessment

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| --- |
| ProblemIs the problem a priority? |
| Judgement | Research evidence | Additional considerations |
| ○ No○ Probably no● Probably yes○ Yes○ Varies○ Don't know | Human body water accounts for 50-70% of the total body mass but, despite this abundance, it is regulated within narrow ranges. During prolonged exercise, sweat losses generally exceed fluid intake and even low levels of dehydration (about 2% of the body mass) already impair thermoregulation (Kenefick 2018, 1) and cardiovascular strain (Crandall 2010, 407; Adams 2014, 686). When these dysfunctions are allowed to progress, they can lead to impaired physical and cognitive performance (Masento 2014, 1841; Savoie 2015, 1207), syncope due to hypotension and, finally, heat illness that can be fatal (Carter 2005, 1338). In such situations, it is of utmost importance to promote post-exercise drinking to restore fluid balance. For rapid and complete rehydration, the drink volume and composition are key (Osterberg 2010, 245; James 2015, 521). Although the NATA states that up to 150% of the estimated fluid deficit needs to be consumed to effectively replace fluid losses after exercise over a short recovery period (less than 4 hours) (McDermott 2017, 877), there is no clear endorsement regarding the specific type of rehydrating fluid. |  |
| Desirable EffectsHow substantial are the desirable anticipated effects? |
| Judgement | Research evidence | Additional considerations |
| ○ Trivial● Small○ Moderate○ Large○ Varies○ Don't know | One study showed a significant increased **serum sodium concentration** 1 h after drinking fresh coconut water, when compared with drinking water (MD, 2 mmol/l; 95% CI could not be calculated; P<0.05). However, another study could not demonstrate a significant difference in serum sodium concentration 1 h after drinking fresh coconut water when compared with drinking water. One study showed a significant increase in **serum osmolality** 1 h after drinking fresh coconut water when compared with water (MD, 3 mOsm/kg; 95% CI could not be calculated; P<0.05). However, another study could not demonstrate a significant difference in serum osmolality 1 h after drinking fresh coconut water when compared with drinking water.One study could not demonstrate a significant difference in plasma osmolality 2 h after drinking fresh coconut water when compared with drinking water. However, the same study showed a significant increase in **plasma osmolality** 2 h after drinking coconut water from concentrate when compared with drinking water (MD, 1.5; 95% CI could not be calculated; P=0.049).Very low certainty evidence (downgraded for risk of bias, imprecision and strongly suspected publication bias) from 2 studies could not demonstrate a significant difference in **nausea** immediately after drinking fresh coconut water when compared with water. On the other hand, low certainty evidence (downgraded for risk of bias and imprecision) from one study showed a significant decrease in **nausea** immediately after and 1 h after drinking fresh coconut water, when compared with drinking water (MD, -1.75 and MD, -1.25 (1-5 scale); respectively; 95% CI could not be calculated; P<0.05). In one study a difference in nausea 1 h after drinking fresh coconut water could not be demonstrated, when compared with drinking water.Low certainty evidence from one study showed a significant decrease in **stomach upset** immediately after drinking fresh coconut water when compared with water (MD, -1, 95% CI could not be calculated; P<0.05). However, in 2 other studies of low certainty (downgraded for risk of bias and imprecision), a significant difference for stomach upset immediately after drinking fresh coconut water could not be demonstrated, when compared with water. Low certainty evidence from one study could also not demonstrate a significant difference for stomach upset immediately after drinking coconut water from concentrate when compared with drinking water.  | Exertion-related dehydration was characterized by an increase in directly measured serum/plasma osmolality and electrolyte concentrations because sweat is hypotonic relative to plasma (Hooper 2015, e008846). During rehydration, restoring and maintaining high levels of plasma and serum osmolality and electrolyte concentrations is desirable and avoids the stimulation of diuresis. A rapid fall in these outcome measures during rehydration will indeed stimulate urine output and increases the risk of developing (symptoms of) hyponatremia.Patient satisfaction outcomes (thirst, stomach fullness, bloating, nausea) were measured with a Visual Analogue Scale (VAS). Lower scores are beneficial when assessing patient satisfaction after drinking. |
| Undesirable EffectsHow substantial are the undesirable anticipated effects? |
| Judgement | Research evidence | Additional considerations |
| ○ Large○ Moderate○ Small● Trivial○ Varies○ Don't know | Low certainty evidence (downgraded for risk of bias and imprecision) from one study could not demonstrate a significant difference for stomach upset 1 h after drinking fresh coconut water or coconut water from concentrate when compared with drinking water. However, the same study showed a significant increase in **stomach upset** 2 h after drinking fresh coconut water or coconut water from concentrate when compared with water (MD, 1.84 (1-5 scale) and MD, 1.47; respectively; 95% CI could not be calculated; P<0.05). | Patient satisfaction outcomes (thirst, stomach fullness, bloating, nausea) were measured with a Visual Analogue Scale (VAS). Lower scores are beneficial when assessing patient satisfaction after drinking. |
| Certainty of evidenceWhat is the overall certainty of the evidence of effects? |
| Judgement | Research evidence | Additional considerations |
| ● Very low○ Low○ Moderate○ High○ No included studies | Downgraded for serious risk of bias, imprecision and for some studies, publication bias was strongly suspected.  | Bias was assessed per study and patient satisfaction outcomes were assessed separately, since for these outcomes, lack of blinding may influence the outcome assessment. |
| ValuesIs there important uncertainty about or variability in how much people value the main outcomes? |
| Judgement | Research evidence | Additional considerations |
| ○ Important uncertainty or variability○ Possibly important uncertainty or variability● Probably no important uncertainty or variability○ No important uncertainty or variability |  |  |
| Balance of effectsDoes the balance between desirable and undesirable effects favor the intervention or the comparison? |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison○ Probably favors the comparison○ Does not favor either the intervention or the comparison● Probably favors the intervention○ Favors the intervention○ Varies○ Don't know | The beneficial effects probably outweigh the undesirable effects for one outcome in one study. |  |
| Resources requiredHow large are the resource requirements (costs)? |
| Judgement | Research evidence | Additional considerations |
| ○ Large costs● Moderate costs○ Negligible costs and savings○ Moderate savings○ Large savings○ Varies○ Don't know |  | VitaCoco (fresh coconut water) costs 3.33£ per liter (Amazon).In places where coconuts do not grow naturally, the costs will be higher and coconut water will therefor require more resources. |
| Certainty of evidence of required resourcesWhat is the certainty of the evidence of resource requirements (costs)? |
| Judgement | Research evidence | Additional considerations |
| ○ Very low○ Low○ Moderate○ High● No included studies |  |  |
| Cost effectivenessDoes the cost-effectiveness of the intervention favor the intervention or the comparison? |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison○ Probably favors the comparison○ Does not favor either the intervention or the comparison○ Probably favors the intervention○ Favors the intervention○ Varies● No included studies |  |  |
| EquityWhat would be the impact on health equity? |
| Judgement | Research evidence | Additional considerations |
| ○ Reduced● Probably reduced○ Probably no impact○ Probably increased○ Increased○ Varies○ Don't know | Coconut water is by far the leading plant-based water available for sale worldwide. In 2016, coconut water accounted for 96 percent of the volume share in the global sale of all plant-based water with over 700 million liters sold and with a market value of about 2.2 billion U.S. dollars. <https://www.statista.com/topics/3500/coconut-water/#:~:text=Coconut%20water%20is%20by%20far,about%202.2%20billion%20U.S.%20dollars> | In places where coconuts do not grow naturally, the cost for coconut water is high, and may therefor lead to reduced equity. |
| AcceptabilityIs the intervention acceptable to key stakeholders? |
| Judgement | Research evidence | Additional considerations |
| ○ No○ Probably no● Probably yes○ Yes○ Varies○ Don't know |  | Coconut water is probably an acceptable intervention to key stakeholders.Coconut water has a certain taste and might not be favoured by everyone. |
| FeasibilityIs the intervention feasible to implement? |
| Judgement | Research evidence | Additional considerations |
| ○ No○ Probably no● Probably yes○ Yes○ Varies○ Don't know |  | The cost may be the biggest factor in feasibility. It is probably more feasible in places where coconuts grow naturally. |

# Summary of judgements

|  | **Judgement** |
| --- | --- |
| **Problem** | No | Probably no | **Probably yes** | Yes |  | Varies | Don't know |
| **Desirable Effects** | Trivial | **Small** | Moderate | Large |  | Varies | Don't know |
| **Undesirable Effects** | Large | Moderate | Small | **Trivial** |  | Varies | Don't know |
| **Certainty of evidence** | **Very low** | Low | Moderate | High |  |  | No included studies |
| **Values** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability |  |  |  |
| **Balance of effects** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | Don't know |
| **Resources required** | Large costs | **Moderate costs** | Negligible costs and savings | Moderate savings | Large savings | Varies | Don't know |
| **Certainty of evidence of required resources** | Very low | Low | Moderate | High |  |  | **No included studies** |
| **Cost effectiveness** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **Equity** | Reduced | **Probably reduced** | Probably no impact | Probably increased | Increased | Varies | Don't know |
| **Acceptability** | No | Probably no | **Probably yes** | Yes |  | Varies | Don't know |
| **Feasibility** | No | Probably no | **Probably yes** | Yes |  | Varies | Don't know |

# Type of recommendation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Strong recommendation against the intervention | Conditional recommendation against the intervention | Conditional recommendation for either the intervention or the comparison | **Conditional recommendation for the intervention** | Strong recommendation for the intervention |
| ○  | ○  | ○  | **●**  | ○  |

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| --- |
| Question 4: |
| **Should beer (0%-5% alcohol) vs. water be used for rehydration after exertion-related dehydration?** |
| **Population:** | Rehydration after exertion-related dehydration |
| **Intervention:** | Beer (0-5% alcohol) |
| **Comparison:** | Water |
| **Main outcomes:** | Cumulative urine; Fluid balance; Plasma volume change; Serum sodium concentration; Hematocrit. |
| **Setting:** | Out-of-hospital setting, experimental cross-over design |
| **Perspective:** | Guideline developers on behalf of individuals |
| **Background:** | Strenuous exercise leads to increased heat production and sweating, which in turn can lead to loss of fluid and electrolytes. If not compensated, thermoregulatory processes will be disrupted, which can have detrimental effects on physiological function and exercise performance. Restoration of fluid balance after exercise can help to minimize this. The electrolyte balance of the ingested fluid plays a key role in the rehydration process. |
| **Conflict of interests:** | None reported |

# Assessment

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| --- |
| ProblemIs the problem a priority? |
| Judgement | Research evidence | Additional considerations |
| ○ No○ Probably no● Probably yes○ Yes○ Varies○ Don't know | Human body water accounts for 50-70% of the total body mass but, despite this abundance, it is regulated within narrow ranges. During prolonged exercise, sweat losses generally exceed fluid intake and even low levels of dehydration (about 2% of the body mass) already impair thermoregulation (Kenefick 2018, 1) and cardiovascular strain (Crandall 2010, 407; Adams 2014, 686). When these dysfunctions are allowed to progress, they can lead to impaired physical and cognitive performance (Masento 2014, 1841; Savoie 2015, 1207), syncope due to hypotension and, finally, heat illness that can be fatal (Carter 2005, 1338). In such situations, it is of utmost importance to promote post-exercise drinking to restore fluid balance. For rapid and complete rehydration, the drink volume and composition are key (Osterberg 2010, 245; James 2015, 521). Although the NATA states that up to 150% of the estimated fluid deficit needs to be consumed to effectively replace fluid losses after exercise over a short recovery period (less than 4 hours) (McDermott 2017, 877), there is no clear endorsement regarding the specific type of rehydrating fluid.  | Alcohol inhibits arginine vasopressin release, and beverages with an alcohol content above 2% reduce fluid retention during rehydration. However, in well-hydrated individuals, rehydration with beverages containing up to 4% alcohol did not increase urine output. Research also suggests that the influence of hypovolemia on renal fluid retention is more potent than the diuretic effect of alcohol. Drinks with increasing alcohol content (greater than 4%) facilitate excessive diuresis and should be discouraged for fluid replacement. (McDermott 2017, 877).  |
| Desirable EffectsHow substantial are the desirable anticipated effects? |
| Judgement | Research evidence | Additional considerations |
| ● Trivial○ Small○ Moderate○ Large○ Varies○ Don't know | No desirable effects reported |  |
| Undesirable EffectsHow substantial are the undesirable anticipated effects? |
| Judgement | Research evidence | Additional considerations |
| ○ Large○ Moderate● Small○ Trivial○ Varies○ Don't know | Regular beer (4.5-5% alcohol) vs waterVery low certainty evidence (downgraded for risk of bias, imprecision and lack of data, and suspected publication bias) from 2 studies could not demonstrate a significant difference in **cumulative urine output** from drinking regular beer compared with drinking water. However, in one study, drinking regular beer compared with water, resulted in a statistically significant increase of cumulative urine output (MD, 444 ml; 95% CI could not be calculated, P=0.043). No undesirable effects reported for 0.5-2% beer or 0% beer. | When consuming a fixed volume of beverage, a reduced urine output indicates a better retention of the consumed beverage and, hence, stimulates the rehydration process. |
| Certainty of evidenceWhat is the overall certainty of the evidence of effects? |
| Judgement | Research evidence | Additional considerations |
| ● Very low○ Low○ Moderate○ High○ No included studies | Evidence downgraded for serious risk of bias and imprecision. In some studies, publication bias is strongly suspected.  | Bias was assessed per study and patient satisfaction outcomes were assessed separately, since for these outcomes, lack of blinding may influence the outcome assessment.  |
| ValuesIs there important uncertainty about or variability in how much people value the main outcomes? |
| Judgement | Research evidence | Additional considerations |
| ○ Important uncertainty or variability○ Possibly important uncertainty or variability● Probably no important uncertainty or variability○ No important uncertainty or variability |  |  |
| Balance of effectsDoes the balance between desirable and undesirable effects favor the intervention or the comparison? |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison○ Probably favors the comparison● Does not favor either the intervention or the comparison○ Probably favors the intervention○ Favors the intervention○ Varies○ Don't know | Beer (in any percentage) does not seem to have any beneficial effects, compared with water. There may be small undesirable effects (increased cumulative urine for 4.6% beer in one study). |  |
| Resources requiredHow large are the resource requirements (costs)? |
| Judgement | Research evidence | Additional considerations |
| ○ Large costs○ Moderate costs○ Negligible costs and savings○ Moderate savings○ Large savings● Varies○ Don't know | The cost for a pint ranges from £0.32 in Venezuela up to £10.86 in Qatar.(<https://www.finder.com/uk/international-pint-price-map>) The monthly cost of water for a family of 4 is 115.50 USD per 150 gal or 0.77 USD per gallon.<https://www.circleofblue.org/2019/world/2019-price-of-water/> | In some places, beer is cheaper and more available than water.  |
| Certainty of evidence of required resourcesWhat is the certainty of the evidence of resource requirements (costs)? |
| Judgement | Research evidence | Additional considerations |
| ○ Very low○ Low○ Moderate○ High● No included studies |  |  |
| Cost effectivenessDoes the cost-effectiveness of the intervention favor the intervention or the comparison? |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison● Probably favors the comparison○ Does not favor either the intervention or the comparison○ Probably favors the intervention○ Favors the intervention○ Varies○ No included studies |  | No significant differences for almost all outcomes, water is most of the time cheaper than beer.  |
| EquityWhat would be the impact on health equity? |
| Judgement | Research evidence | Additional considerations |
| ○ Reduced● Probably reduced○ Probably no impact○ Probably increased○ Increased○ Varies○ Don't know |  | Beer may not be easily available in all parts of the world. It is not consumed by all populations (e.g. because of age or religion). In addition, in most places, beer is more expensive than water. |
| AcceptabilityIs the intervention acceptable to key stakeholders? |
| Judgement | Research evidence | Additional considerations |
| ○ No● Probably no○ Probably yes○ Yes○ Varies○ Don't know | The use of alcoholic beverages may have other unwanted effects and is probably not recommended as a rehydration beverage for competitive athletes. Moreover, alcohol may have a diuretic effect, which increases with increasing alcohol levels (Maughan 2016, 717).  | Due to the (often) higher cost of beer and some populations that don't drink beer, this may be less acceptable. |
| FeasibilityIs the intervention feasible to implement? |
| Judgement | Research evidence | Additional considerations |
| ○ No● Probably no○ Probably yes○ Yes○ Varies○ Don't know |  | Beer would be less feasible due to cost, acceptability and the risk of intoxication with higher alcohol percentages.  |

# Summary of judgements

|  | **Judgement** |
| --- | --- |
| **Problem** | No | Probably no | **Probably yes** | Yes |  | Varies | Don't know |
| **Desirable Effects** | **Trivial** | Small | Moderate | Large |  | Varies | Don't know |
| **Undesirable Effects** | Large | Moderate | **Small** | Trivial |  | Varies | Don't know |
| **Certainty of evidence** | **Very low** | Low | Moderate | High |  |  | No included studies |
| **Values** | Important uncertainty or variability | Possibly important uncertainty or variability | **Probably no important uncertainty or variability** | No important uncertainty or variability |  |  |  |
| **Balance of effects** | Favors the comparison | Probably favors the comparison | **Does not favor either the intervention or the comparison** | Probably favors the intervention | Favors the intervention | Varies | Don't know |
| **Resources required** | Large costs | Moderate costs | Negligible costs and savings | Moderate savings | Large savings | **Varies** | Don't know |
| **Certainty of evidence of required resources** | Very low | Low | Moderate | High |  |  | **No included studies** |
| **Cost effectiveness** | Favors the comparison | **Probably favors the comparison** | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | No included studies |
| **Equity** | Reduced | **Probably reduced** | Probably no impact | Probably increased | Increased | Varies | Don't know |
| **Acceptability** | No | **Probably no** | Probably yes | Yes |  | Varies | Don't know |
| **Feasibility** | No | **Probably no** | Probably yes | Yes |  | Varies | Don't know |

# Type of recommendation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Strong recommendation against the intervention | Conditional recommendation against the intervention | **Conditional recommendation for either the intervention or the comparison** | Conditional recommendation for the intervention | Strong recommendation for the intervention |
| ○  | ○  | **●**  | ○  | ○  |

# Conclusions

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| Recommendation |
| We recommend the use of any readily available rehydration drink or water for treating exertion related dehydration in the first aid setting. (Good Practice Statement)We suggest rehydration for exertion-related dehydration using a 4-9% carbohydrate-electrolyte drink. Alternative rehydration options include 0-3.9% carbohydrate-electrolyte drinks, water, coconut water or skim or low-fat cow's milk (weak recommendation, very low certainty evidence). There is insufficient evidence to recommend for or against rehydration with beer (0-5% alcohol). |
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| Justification |
| Although there is variability among the identified studies, we identified a potential beneficial effect with use of CE drinks compared with water for many of the reviewed outcomes. Differences seen in urine production between the various drinks used for rehydration were discussed by the task force and are likely a result of the drink composition. Ingested drinks with high energy content (i.e. from carbohydrate, fat, protein or alcohol) will empty from the stomach more slowly than drinks containing no energy. They will therefore potentially reduce or delay diuresis when compared with water. In other words, when large volumes of dilute drinks are consumed, a fall in serum electrolyte concentrations and osmolality occurs and urine production and excretion are stimulated. However, if the electrolyte concentration of a rehydration drink is high, this will maintain high serum or plasma electrolyte concentration and osmolality, reducing the excretion of dilute urine. As a consequence, low cumulative urine outputs and, hence, high net fluid balances can be associated with improved fluid retention and, hence, effective rehydration.In cases of exertional dehydration, it is most important to rehydrate as soon as possible. The choice will often be made based on what the dehydrated person is willing to drink; the drink needs to be palatable to increase patient compliance with the need for increased fluid intake. This is suggested as a good practice statement. First aid providers are commonly recruited to assist at first aid stations located at sporting and challenge events where exercise-induced dehydration is a common problem. It may not be possible to determine the exact quantity or percent of fluid loss in the first aid setting, nor the volume required for adequate rehydration. This PICO question specifically looked at sodium levels reported after rehydration in the included studies and agreed that oral rehydration with CE drinks may assist in preventing hyponatremia, although this review did not specifically address exercise-associated hyponatremia. In addition, all included studies conducted exercise in a controlled environment and for a specific time period. Extreme events such as ultramarathons were not included in the evidence evaluation.Excessive fluid consumption may lead to an electrolyte imbalance, specifically, a drop in plasma/serum sodium concentration. This reduction in sodium concentration may result in clinical hyponatremia, a rare condition but not infrequently seen in endurance athletes. Signs and symptoms of exertional hyponatremia include excessive drinking, nausea, vomiting, dizziness, muscular twitching, peripheral tingling or swelling, headache, disorientation, altered mental status, physical exhaustion, pulmonary edema, seizures, and cerebral edema.If clean, drinkable water is available, its cost, relative to CE drinks, make it an acceptable alternative. However, water may require a longer time to rehydrate and, in some cases, may be associated with an increased risk of hyponatremia. |

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| Subgroup considerations |
| Skim or low-fat cow's milk appears to have a similar water, energy and macronutrient content as sports drinks. This explains the beneficial effects of milk on rehydration. However, rehydration with milk may be associated with other issues of patient satisfaction or compliance when compared with water. The Task Force discussed that the use of alcoholic beverages may have other unwanted effects and is probably not recommended as a rehydration beverage for competitive athletes. Moreover, alcohol may have a diuretic effect, which increases with increasing alcohol levels.  |

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| Implementation considerations |
| In some regions, the prevalence of lactose intolerance is higher than in other regions, making milk a less suitable rehydration solution. The use of milk by people with lactose intolerance may induce adverse effects such as diarrhea, which could hamper the effects of rehydration. A further challenge is that milk generally needs refrigeration, which may not always be accessible.Coconut water may be more costly in geographic regions where fresh coconuts are not readily available. In addition, some people may find coconut water less palatable than water. |

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| Monitoring and evaluation |
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| Research priorities |
| How can a first aid provider determine the amount of liquid required for rehydration?How can a first aid provider determine the amount of time required to ensure adequate rehydration?How can a first aid provider determine the chemical composition of available rehydration products? |

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