# Milk and Rehydration after Sport

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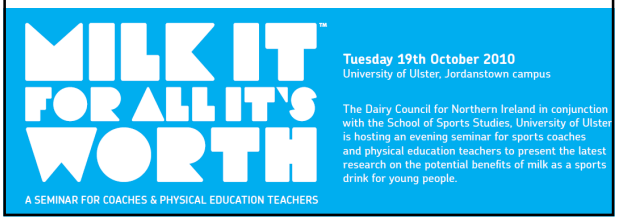



# Outline

Why rehydration after exercise ?

Post-exercise rehydration
- Volume
- Sodium and Potassium
- Energy

Milk as a rehydration drink

# Why is hydration important?

Dehydration, if sufficiently severe can cause:

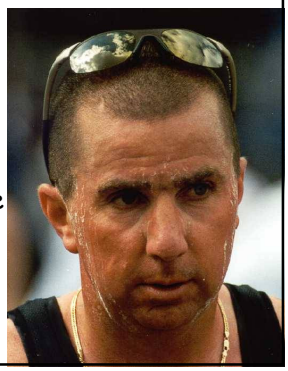
Reduced exercise performance
Reduced blood volume
Increased heart rate
Reduced skin & muscle blood flow
Impaired thermoregulation
Increased perception of effort
Headache, nausea, insomnia
Impaired mental function
Increased risk of heat illness

# Water and Salt Losses in Exercise

Sweat loss normally exceeds fluid intake: some dehydration is normal

Electrolyte composition of sweat is highly variable: main electrolyte lost is sodium

Athletes finish exercise with both fluid and electrolyte deficits



# Post-exercise hydration

"After exercise, the goal is to fully replace any fluid and electrolyte deficit. If recovery time and opportunities permit, consumption of normal meals and snacks with a sufficient volume of plain water will restore euhydration, provided the food contains sufficient sodium to replace sweat losses. If dehydration is substantial with a relatively short recovery period (<12 h) then aggressive rehydration programs may be merited."

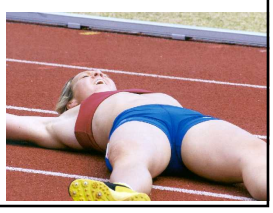

# Recovery after exercise

Hydration/fluid balance restoration

Muscle glycogen restoration

Muscle protein synthesis

Restore homeostasis
eg Reduce temperature



## Sweat volume and electrolyte losses

## Fluid balance in football

Players (n = 26) weighed pre/post training

All drinks bottles also weighed

Mean mass loss = 1.23 (0.50-2.55) kg

Mean drink intake = 972 (239-1724) ml

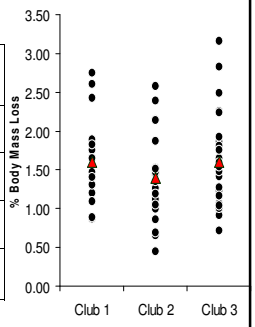
Mean sweat loss = 2.19 (1.67-3.14) l

Mean sweat rate = 1.46 (1.12-2.09) l/h

Dehydration = 1.6 (0.7-3.2) %

## Sweat loss in football players

| | Sweat loss (l) | Fluid intake (ml) | % Decrease in body mass |
|---|---|---|---|
| Club 1 (n=17) | 1.7 ± 0.4<br>1.1-2.6 | 420 ± 220<br>40-950 | 1.6 ± 0.6<br>0.9-2.8 |
| Club 2 (n=24) | 2.0 ± 0.4<br>1.3-2.8 | 970 ± 300<br>270-1660 | 1.4 ± 0.5<br>0.5-2.6 |
| Club 3 (n=26) | 2.2 ± 0.4<br>1.7-3.1 | 970 ± 340<br>240-1720 | 1.6 ± 0.6<br>0.7-3.2 |
| **Overall (n=67)** | **2.0 ± 0.4**<br>1.1-3.1 | **830 ± 380**<br>40-1720 | **1.5 ± 0.5**<br>0.5-3.2 |




Maughan et al (2004). *Int J Sports Nutr Exerc Metab*, **14**, 333-346;
Maughan et al (2005). *J Sports Sci*, **23**, 73-79;
Shirreffs et al (2005) *Int J Sports Med*, **26**, 90-95.
Shirreffs et al (2006) *J Sports Sci*, 24, 699-707.

## Individual variations

| Temp (°C) | RH (%) | n | Sweat loss (ml) | Fluid intake (ml) | Dehydration (%) | Sweat Na (mmol/l) | Salt loss (g) |
|---|---|---|---|---|---|---|---|
| 32 | 20 | 26 | 1670-3140 | 239-1724 | 0.71-3.16 | 16-66* | 1.5-7.5* |
| 27 | 55 | 24 | 1385-2382 | 265-1661 | 0.45-2.58 | 26-67 | 3.1-7.7 |
| 28 | 56 | 20 | 1515-2895 | 721-2278 | -0.24-2.30 | 18-70 | 2.2-9.9 |
| 25 | 60 | 24 | 884-3100 | 243-2057 | -0.24-2.60 | 21-81 | 2.1-9.6 |
| 5 | 81 | 16 | 1060-2650 | 44-951 | 1.06-2.65 | 16-66 | 1.7-7.0 |

## Outline

Why rehydration after exercise ?

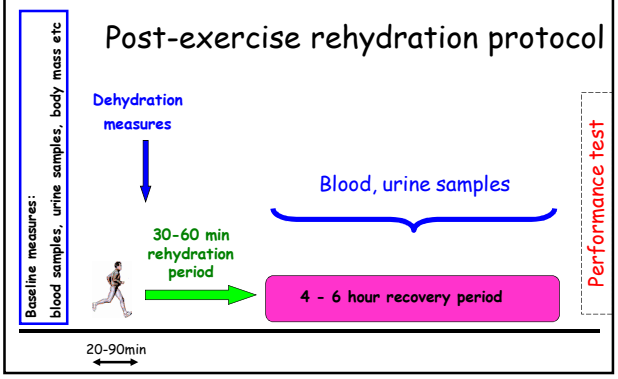
Post-exercise rehydration

- The role of sodium
- Drink delivery rate
- Potassium

Milk as a rehydration drink

## Recovery of fluid and electrolyte balance after exercise

Post-exercise rehydration protocol



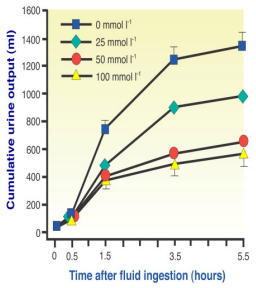
## Effects of Added Sodium (1)

Dehydration : 2% of body

Fluid intake after exercise: 3% of body mass (2.1 l)

Drinks contained sodium at concentrations of 0, 25, 50 and 100 mmol/l

Rehydration assessed by collection of urine output over the next 5.5 hours

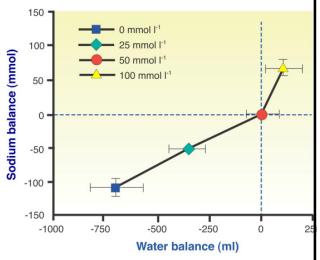



*Maughan et al Eur J Appl Physiol 1995; 71: 311-319*

## Effects of Added Sodium (2)

Whole body fluid balance is closely related to whole body sodium balance.

Restoration of fluid balance was achieved when the drinks contained about 50 mmol/l sodium - about the same as the sweat sodium concentration.




## CONCLUSION

Even when large volumes of fluid are ingested after exercise, urine loss may cause a rapid return to a hypohydrated state.

Urine output is inversely proportional to the sodium content of rehydration drinks.

Positive fluid balance is maintained only when the sodium content of the drink is high.

*Maughan et al Eur J Appl Physiol 1995; 71: 311-319*

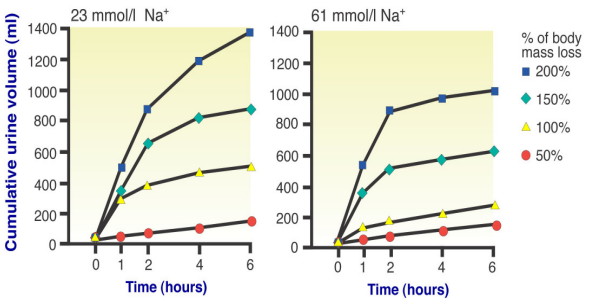
## Volume and Composition (1)

Interaction of volume of fluid consumed and sodium concentration on the efficacy of rehydration after sweat loss of 2% of body mass.

Two subject groups:
- Low (23 mmol/l) sodium
- High (61 mmol/l) sodium

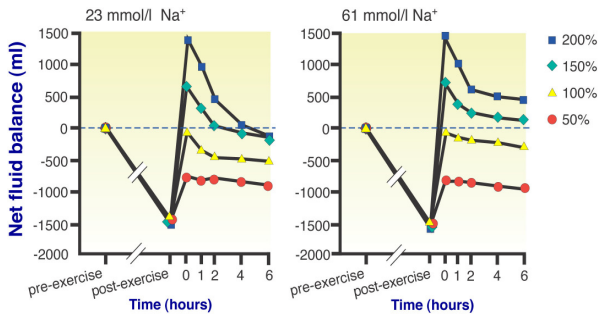
Four Volume trials:
- 50% of weight loss
- 100% of weight loss
- 150% of weight loss
- 200% of weight loss

## Urine excretion during recovery




Urine collected over 6h after rehydration
Excretion related to volume consumed
Shirreffs et al, 1996

## Whole body fluid balance status




6h after rehydration:
Hypohydration with 50 & 100%
With 23 Na+, euhydration with 150 and 200%
With 61 Na+, euhydration with 150%
With 61 Na+, hyperhydration with 200%

# CONCLUSION

Unless sufficient volume is consumed after dehydration, the body remains in net negative fluid balance.

If the electrolyte (sodium) content of drinks is low, positive fluid balance is not maintained, even when the volume consumed is large.

Positive fluid balance is achieved when both volume and sodium content of drinks are high. It is probably necessary to drink about 1.5 litres for each litre of sweat loss.

*Shirreffs et al Med Sci Sports Ex.1996; 28: 1260-1271*

# Drinking after exercise
# The source of the electrolytes ?

Hypohydration = 2.1 % body mass

Fluid volume = 150 % mass loss

Meal = 63kJ/kg body mass

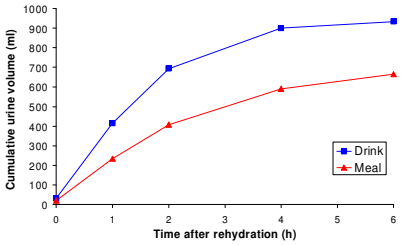
Treatments:

This study investigated whether solid food plus water was as good for rehydration as a commercial sports drink.

| | SPORTS DRINK | DRINK + MEAL |
|---|---|---|
| $Na^+$ | 21 mmol/l | 1 mmol/l + 0.118 mmol/kJ |
| $K^+$ | 3.4 mmol/l | 0.4 mmol/l + 0.061 mmol/kJ |

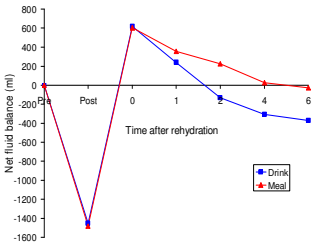
Maughan et al, 1996

# Urine excretion during recovery




There was more urine production in the 6 hours after consumption of the sports drink. The sodium and potassium content of the sports drink was less than that of the meal. *Maughan et al, 1996*

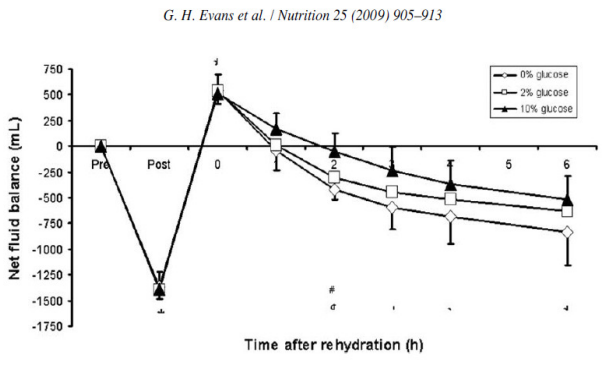
# Whole body fluid balance status




At the end, the subjects were better hydrated after drinking water with a meal than after drinking only the sports drink.

This might suggest that there is no role for sports drinks after exercise, but few athletes like to eat large amounts of food soon after hard exercise. Liquids may be the best option when another exercise session follows soon afterwards.

# Effects of energy content




# Rehydration after exercise

1. Adequate volume must be consumed Shirreffs et al, (1996) MSSE, 28: 1260-1271
2. Sodium concentration must be moderately high in relation to sweat losses Shirreffs & Maughan (1998) AJP, 274: F868-F875
3. The sodium can be obtained from the rehydration drink or from food Maughan et al, (1996) EJAP, 73: 317-325; Ray et al, (1998)
4. A significant effect of potassium has not been clearly identified Maughan et al, (1994) EJAP, 69: 209-215; 19. Shirreffs et al, (2007) IJSNEM, 17, 244-258
5. Increasing energy content slows gastric emptying and prevents diuresis Evans et al (2009) Nutrition 25, 905-913

# Outline

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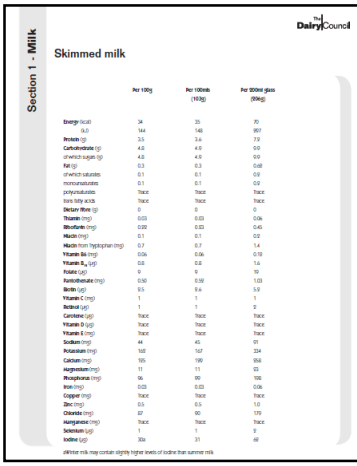
Milk as a rehydration drink


Section 1 - Milk

Skimmed milk

Dairy Council

# Composition of skimmed milk (UK)

Water
Energy
Sodium
Potassium

## Milk as a post-exercise rehydration drink

*Shirreffs et al, Br J Nutr, 2007*

**BACKGROUND**

Milk is a potential candidate for an effective post-exercise solution, given its naturally high electrolyte content and the presence of carbohydrate in a concentration similar to many commercially available sports drinks.

**AIM**

To investigate the effectiveness of low-fat milk at restoring whole-body net fluid balance following mild exercise-induced dehydration

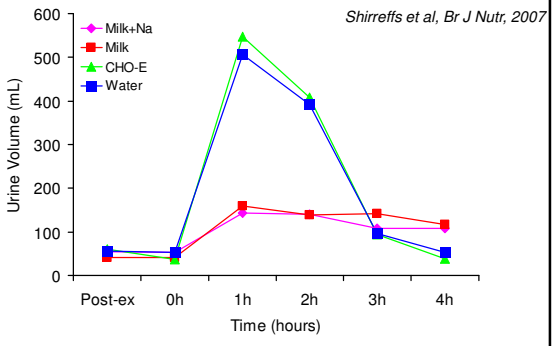
**METHODS**

11 subjects (5 male, 6 females)
Intermittent exercise in the heat to lose 1.2±0.3kg (1.8±0.2%) of body mass.
Rehydrated after exercise by drinking 150% of sweat volume lost ie 1.79±0.42 litres.

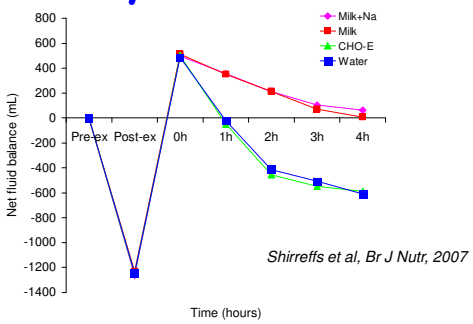
- Plain water
- Sports drink (carbohydrate-electrolyte solution)
- 0.1% fat milk
- 0.1% fat milk with added NaCl

## Urine production during recovery

*Shirreffs et al, Br J Nutr, 2007*




## Whole body net fluid balance




*Shirreffs et al, Br J Nutr, 2007*

Subjects remained in positive fluid balance or euhydrated throughout recovery after drinking the milk drinks but returned to net negative fluid balance 1 h after drinking the other drinks

## Milk as a post-exercise rehydration drink

Milk can be an effective post-exercise rehydration drink and can be considered for use after exercise by anyone except those individuals who have lactose intolerance

*Shirreffs et al, Br J Nutr, 2007*

## Can milk ingestion help subsequent performance?

*Watson et al, Eur J Appl Physiol, 2008*

**AIM**

Can milk ingestion after exercise help subsequent performance?

**METHODS**

7 males

Intermittent exercise in the heat to lose 1.52±0.17kg (2.0±0.1%) body mass.

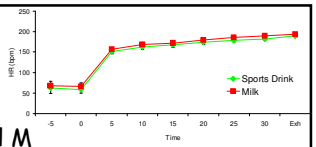
Rehydration with a volume equivalent to 150% body mass loss ie 2270±245mL

Sports drink (carbohydrate-electrolyte solution)

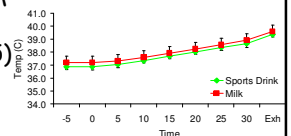
0.1% fat milk

At the end of the 3 h recovery period, an exercise capacity test was completed at 61% VO2peak in warm (35.3±0.5°C), humid (63±2%) conditions

## Exercise performance

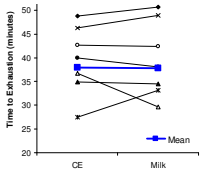



HR (P=0.02) higher on trial M




Rectal temperature (P=0.045) higher on trial M

No difference in exercise time to exhaustion between trials (39.6±7.3 min vs. 39.7±8.1 min on trials CE and M, respectively)

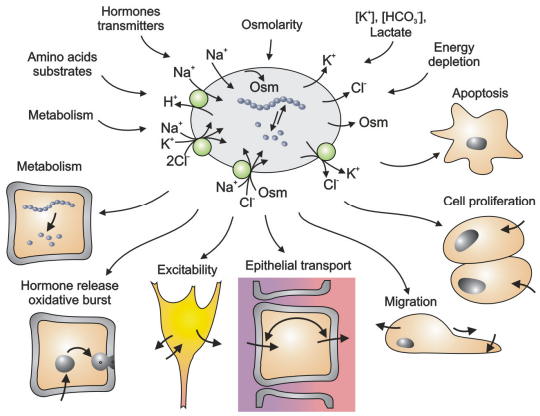



Watson et al, Eur J Appl Physiol, 2008

## Study conclusions

Despite the effect on fluid retention, exercise capacity was not different between skimmed milk and a commercially available carbohydrate-electrolyte drink 4 h following exercise/heat-induced body mass loss

*Watson et al, Eur J Appl Physiol, 2008*




## Conclusions

Milk can restore and maintain hydration status equally as well as, or better than, a commercially-available sports drink

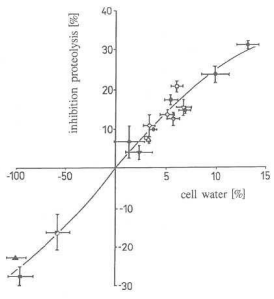
Subsequent performance may be similar to that with a commercially-available sports drink

## Cell Volume and Regulation of Metabolism

Exposure of cultured muscle cells to hypotonic solutions results in cell swelling and promotion of anabolic pathways

Glycogen and protein synthetic rates are both increased

Exposing the same cells to a hypertonic medium causes cell shrinkage and promotes breakdown of glycogen and protein




Thank you for your attention !