New ideas about calcium and bone health in athletes

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updates

Nutrition and Athlete Bone Health

Craig Sale[1] · Kirsty Jayne Elliott-Sale[1]

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Abstract

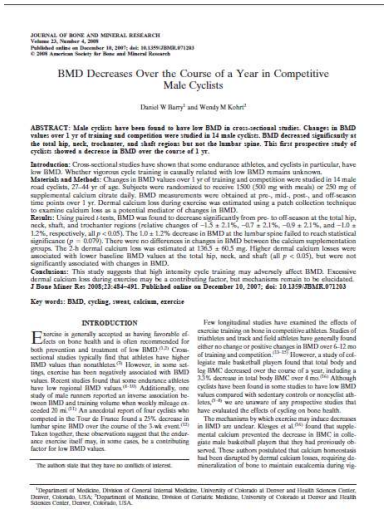
Athletes should pay more attention to their bone health, whether this relates to their longer-term bone health (e.g. risk of osteopenia and osteoporosis) or their shorter-term risk of bony injuries. Perhaps the easiest way to do this would be to modify their training loads, although this advice rarely seems popular with coaches and athletes for obvious reasons. As such, other possibilities to support the athletes' bone health need to be explored. Given that bone is a nutritionally modified tissue and diet has a significant influence on bone health across the lifespan, diet and nutritional composition seem like obvious candidates for manipulation. The nutritional requirements to support the skeleton during growth and development and during ageing are unlikely to be notably different between athletes and the general population, although there are some considerations of specific relevance, including energy availability, low carbohydrate availability, protein intake, vitamin D intake and dermal calcium and sodium losses. Energy availability is important for optimising bone health in the athlete, although normative energy balance targets are highly unrealistic for many athletes. The level of energy availability beyond which there is no negative effect for the bone needs to be established. On the balance of the available evidence it would seem unlikely that higher animal protein intakes, in the amounts recommended to athletes, are not harmful to bone health, particularly with adequate calcium intake. Dermal calcium losses might be an important consideration for endurance athletes, particularly during long training sessions or events. In these situations, some consideration should be given to pre-exercise calcium feeding. The avoidance of vitamin D deficiency and insufficiency is important for the athlete to protect their bone health. There remains a lack of information relating to the longer-term effects of different dietary and nutritional practices on bone health in athletes, something that needs to be addressed before specific guidance can be provided.

Bone health in athletes is often problematic

1. **Loss of bone mineral density or failure to gain optimal BMD during important year is often reported**
2. **Even when BMD is "normal", a high prevalence of bone injuries is often reported**
3. **Bone injuries are particularly harmful to an athletic career**
   - Lengthy recovery time
   - Predict future injuries
4. **Bone health is complex and problems are multi-factorial**
   - Energy availability
   - Carbohydrate availability
   - Vitamin D
   - Bone loading
   - Genetics
   - Calcium?
5. **Some causes of poor bone health in athletes are "occupational hazards"**

Endurance cyclists are a high risk group

- Studies show low bone density in high level male cyclists, and loss of BMD over the course of a season
- Identifiable risk factors
  - Non-weight bearing activity
  - Aerodynamic position



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BMD Decreases Over the Course of a Year in Competitive Male Cyclists

Daniel W Barry[1] and Wendy M Kohrt[2]

ABSTRACT: Male cyclists have been found to have low BMD in cross-sectional studies. Changes in BMD values over 1 yr of training and competition were studied in 14 male cyclists. BMD decreased significantly at the total hip, neck, trochanter, and shaft regions but not the lumbar spine. This first prospective study of cyclists showed a decrease in BMD over the course of 1 yr.

Introduction: Cross-sectional studies have shown that some endurance athletes, and cyclists in particular, have low BMD. Whether vigorous cycle training is causally related with low BMD remains unknown.
Materials and Method: Changes in BMD values over 1 yr of training and competition were studied in 14 male road cyclists, 27–44 yr of age. Subjects were randomized to receive 1500 (500 mg with meals) or 250 mg of supplemental calcium citrate daily. BMD measurements were obtained at pre-, mid-, post-, and off-season time points over 1 yr. Dermal calcium loss during exercise was estimated using a patch collection technique to examine calcium loss as a potential mediator of changes in BMD.
Results: Using paired *t* tests, BMD was found to decrease significantly from pre- to off-season at the total hip, neck, shaft, and trochanter regions (relative changes of −1.3 ± 2.1%, −0.7 ± 2.1%, −0.9 ± 2.1%, and −1.0 ± 1.2%, respectively, all $p < 0.05$). The 1.0 ± 1.2% decrease in BMD at the lumbar spine failed to reach statistical significance ($p > 0.079$). There were no differences in changes in BMD between the calcium supplementation groups. The 2.h dermal calcium loss was estimated at 136.5 ± 40.3 mg. Higher dermal calcium losses were associated with lower baseline BMD values at the total hip, neck, and shaft (all $p < 0.05$), but were not significantly associated with changes in BMD.
Conclusions: This study suggests that high intensity cycle training may adversely affect BMD. Excessive dermal calcium loss during exercise may be a contributing factor, but mechanisms remain to be elucidated.
J Bone Miner Res 2008;23:484–491. Published online on December 10, 2007; doi: 10.1359/JBMR.071203

Key words: BMD, cycling, sweat, calcium, exercise

INTRODUCTION

Exercise is generally accepted as having favorable effects on bone health and is often recommended for both prevention and treatment of low BMD.[1,2] Cross-sectional studies typically find that athletes have higher BMD values than nonathletes.[3] However, in some settings, exercise has been negatively associated with BMD values. Recent studies found that some endurance athletes have low regional BMD values.[4–10] Additionally, one study of male runners reported an inverse association between BMD and training volume when weekly mileage exceeded 20 mi.[11] An anecdotal report of four cyclists who competed in the Tour de France found a 25% decrease in lumbar spine BMD over the course of the 3-wk event.[12] Taken together, these observations suggest that the endurance exercise itself may, in some cases, be a contributing factor for low BMD values.

Few longitudinal studies have examined the effects of exercise training on bone in competitive athletes. Studies of triathletes and track and field athletes have generally found either no change or positive changes in BMD over 6–12 mo of training and competition.[13–15] However, a study of collegiate male basketball players found that total body and leg BMC decreased over the course of a year, including a 3.3% decrease in total body BMC over 4 mo.[16] Although cyclists have been found in some studies to have low BMD values compared with sedentary controls or noncyclist athletes,[4–10] we are unaware of any prospective studies that have evaluated the effects of cycling on bone health.

The mechanisms by which exercise may induce decreases in BMD are unclear. Klingen et al.[16] found that supplemental calcium prevented the decrease in BMC in collegiate male basketball players that they had previously observed. These authors postulated that calcium homeostasis had been disrupted by dermal calcium losses, requiring demineralization of bone to maintain eucalcemia during vig-

The authors state that they have no conflicts of interest.

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Endurance cyclists are a high risk group

- Studies show low bone density in high level male cyclists, and loss of BMD over the course of a season
- Identifiable risk factors
  - Non-weight bearing activity
  - Aerodynamic position
  - Low energy availability

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Michael Rasmussen

From Wikipedia, the free encyclopedia

Michael Rasmussen (born 1 June 1974) is a Danish professional road bicycle racer who rides for the Danish team Christina Watches-Onfone. In the 2007 Tour de France, Rasmussen, while in the yellow jersey, had his contract terminated by his team and was removed from the Tour. He served a two-year ban from July 2007 to July 2009, for lying about his whereabouts.

Specializing in climbing, Rasmussen has shown a propensity for attempting spectacular wins in mountain stages in which he breaks away from the peloton early and rides alone for most of the stage.

Michael Rasmussen is known for his care for detail when considering weight. With a staggeringly low weight (60 kg) he is usually one of the lightest riders in his class. He is known for peeling off unnecessary stickers from his bike, not wearing the Livestrong wristband which has become common among many Tour de France riders, due to the additional grams. He used to count each grain of rice before eating and had water with his breakfast cereal, not milk. He only carries one water bottle holder and his Colnago Extreme-C bike weighed 6.81 kg,[citation needed] only 10 g more than the minimum limit.[1]

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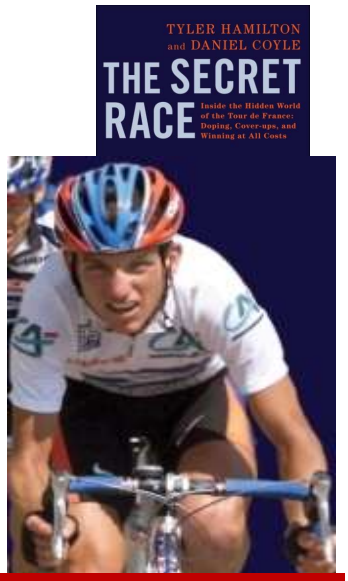
Endurance cyclists are a high risk group

"But the truth is that losing weight works. **If I were given the choice between being three pounds lighter or having three more hematocrit points (via doping), I would take the lighter weight every time."**



The Secret Race, Tyler Hamilton and Daniel Coyle, Bantam Press 2012.

Endurance cyclists are a high risk group

Chris Boardman: transformation from track cyclist to road cyclist (1992 to 1994)

"(My coach) computed what a loss of 1.5 kg would make over a typical hour long climb of an average 8% gradient. The answer was 46 s on the climb, and overall on the tour, about seven minutes".

Endurance cyclists are a high risk group

- Studies show low bone density in high level male cyclists, and loss of BMD over the course of a season
- Identifiable risk factors
  - Non-weight bearing activity
  - Aerodynamic position
  - Low energy availability
  - Inadequate calcium, protein intake
  - Low carb availability ("train low", keto diets)
  - Depressed hormonal profiles (testosterone, IGFs)
  - Corticosteroid use
  - Insufficient Vitamin D status
  - **Dermal Ca losses**

Calcium losses in sweat

Calcium is excreted as a sweat electrolyte

Average sweat calcium loss in basketball training session = 247 mg and requires dietary replacement to manage calcium balance (Klesges et al. 1996)

Calcium excretion in sweat has acute effect on bone turnover

Calcif Tissue Int (2007) 80:359–365
DOI 10.1007/s00223-007-9026-y

Acute Effects of 2 Hours of Moderate-Intensity Cycling on Serum Parathyroid Hormone and Calcium

Daniel W. Barry · Wendy M. Kohrt

2 h cycling session in competitive cyclists: Sweat calcium loss = 140 mg in ~ 2L sweat

Serum Parathyroid hormone (PTH) almost doubled over the session to help defend against a drop in serum ionic calcium

Overall calcium balance vs acute calcium homeostasis

Calcium intake around exercise, calcium losses and calcium homeostasis

Published in final edited form as:
Med Sci Sports Exerc. 2011 April ; 43(4): 617–623. doi:10.1249/MSS.0b013e3181f79fa8.

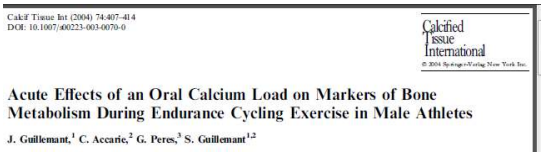
Acute Calcium Ingestion Attenuates Exercise-induced Disruption of Calcium Homeostasis

Daniel W Barry[1], Kent C Hansen[2], Rachael E Van Pelt[2], Michael Witten, Pamela Wolfe, MS[3], and Wendy M Kohrt[2]

35 km cycling time trial (n = 20)
- 1000 mg calcium supplement consumed before TT
- 1000 mg calcium consumed during TT
- Control

- All trials associated with a decrease in serum ionic calcium and increase in CTX (bone breakdown)
- PTH increase with exercise partially suppressed in **pre-ride** Ca supplement trial
- Calcium supplementation did not alter this when adjusted for hemoconcentration
- No correlation between Δ PTH, CTX, BALP and dermal calcium loss (~140 mg)

Calcium intake around exercise, calcium losses and calcium homeostasis


Calcif Tissue Int (2004) 74:407–414
DOI: 10.1007/s00223-003-0070-0

Calcified Tissue International

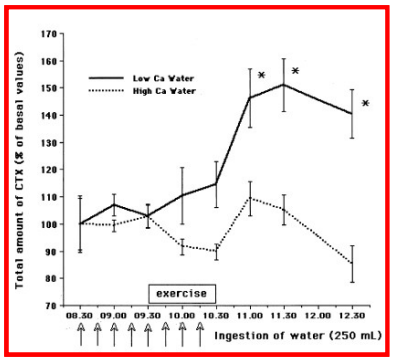
Acute Effects of an Oral Calcium Load on Markers of Bone Metabolism During Endurance Cycling Exercise in Male Athletes

J. Guillemant,[1] C. Accarie,[2] G. Peres,[3] S. Guillemant[1,2]

60 min cycling @ 80% VO2max (n = 12)

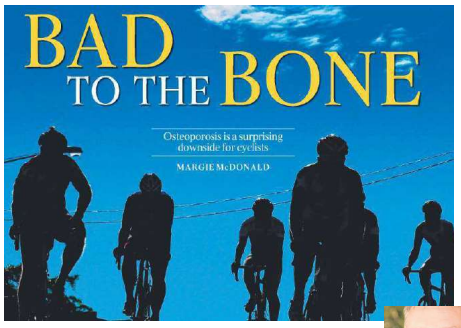
- 1000 mg calcium consumed before and during ride via High Calcium mineral water
- control = low Ca water

- PTH increase with exercise partially suppressed in the high Ca water trial
- Ca replacement abolished the increase in CTX otherwise see during exercise



Dairy intake around exercise, calcium losses and calcium homeostasis

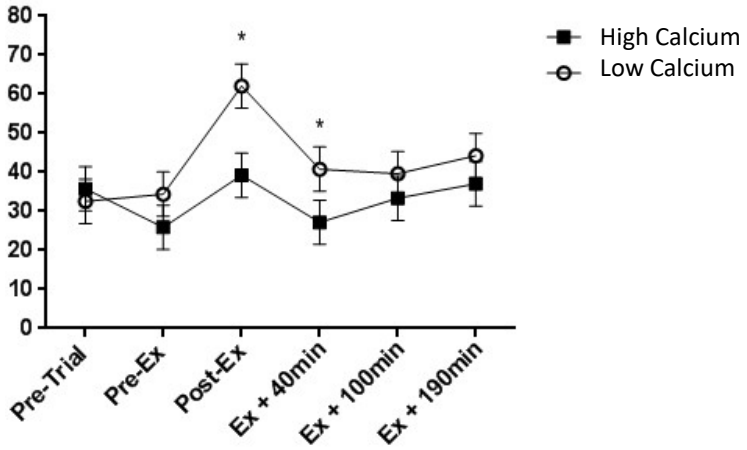
- Female cyclists (n = 32) participating in National Road series
- BMD, body composition, Vitamin D status
- Standardisation
  - Pre-trial diet and training
  - Menstrual phase
  - Time of day of trial
- 2 trials of 90 min cycling
  - 80 min steady state + 10 min TT
- Meal 2 hours pre-ride (matched for energy and carbohydrate (2 g/kg)
  - Low calcium: 1350 ±53 mg
    Oats + Milk + serve of yoghurt
  - High calcium: 46 ±7 mg
    Oats + water + serve of fruit



Dairy Australia

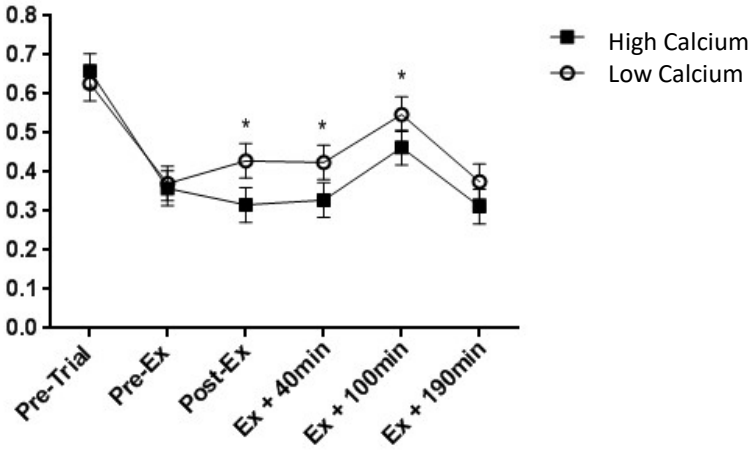
Cycling AUSTRALIA

Effect of high dairy pre-event meal on parathyroid hormone



Haakonssen et al., PloS One 2015;10(5):e0123302.

Effect of high dairy pre-event meal on CTX (bone breakdown)



Haakonssen et al., PloS One 2015;10(5):e0123302.

Effect of high dairy pre-event meal on cycling performance

No statistical or clinical evidence of an effect of meal type on time trial performance

- No difference in mean power
- No effect of meal on pre-exercise gut comfort
- No difference in gut comfort due to meal
- No difference in palatability between meals.

International Journal of Sport Nutrition and Exercise Metabolism, 2014, 24, 553-558
http://dx.doi.org/10.1123/ijsnem.2014-0069
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INTERNATIONAL JOURNAL OF SPORT NUTRITION AND EXERCISE METABOLISM
www.IJSNEM-Journal.com
RAPID COMMUNICATION

Dairy-Based Preexercise Meal Does Not Affect Gut Comfort or Time-Trial Performance in Female Cyclists

Eric C. Haakonssen, Megan L. Ross, Louise E. Cato, Alisa Nana, and Emma J. Knight
Australian Institute of Sport

David G. Jenkins
University of Queensland

David T. Martin and Louise M. Burke
Australian Institute of Sport

Practical recommendations from study of pre-exercise dairy intake

- Pre-ride calcium intake guidelines set for elite Australian cyclists and cycling teams
  - 1000 mg calcium from dairy and/or supplement
- Sub-elite and recreational cyclists could eat pre-ride meal featuring dairy foods and choose dairy drinks during Café rides

Update since 2015
1. Sweat is not the source of calcium "loss"

Same exercise (60 min walking) produces increases in PTH and CTX despite different sweat (Ca) losses

Bone Biomarker Response to Walking under Different Thermal Conditions in Older Adults

SARAH J. WHERRY[1], CHRISTINE M. SWANSON[2], PAMELA WOLFE[1], TOBY WELLINGTON[1], REBECCA S. BOXEI ROBERT S. SCHWARTZ[1,3], and WENDY M. KOHRT[1,3]

Medicine and Science in Sports and Exercise 2019; 51: 1599-1604

Calcium clamp protocol showed that drop in iCa occurs within 15 min of exercise

Author manuscript
J Bone Miner Res. Author manuscript; available in PMC 2019 July 01.

Published in final edited form as:
J Bone Miner Res. 2018 July ; 33(7): 1326–1334. doi:10.1002/jbmr.3428.

Maintenance of Serum Ionized Calcium During Exercise Attenuates Parathyroid Hormone and Bone Resorption Responses

Wendy M Kohrt[1,2], Sarah J Wherry[1], Pamela Wolfe[3], Vanessa D Sherk[4], Toby Wellington[1], Christine M Swanson[4], Connie M Weaver[5], and Rebecca S Boxer[1,2]

Update since 2015
2. Calcium "loss" is complex

- Intensity dependent (?metabolic acidosis, epinephrine)
- Ionic Ca (iCa) rather than total Ca
- Calcium concentrations rather than calcium content (no adjustment for plasma volume needed)

Author manuscript
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J Bone Miner Res. 2018 July ; 33(7): 1326–1334. doi:10.1002/jbmr.3428.

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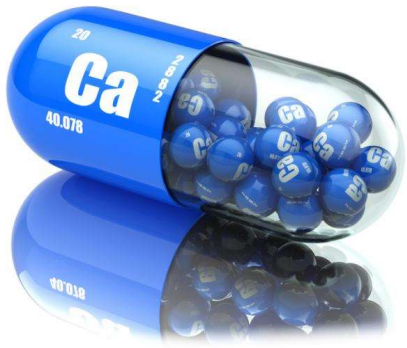
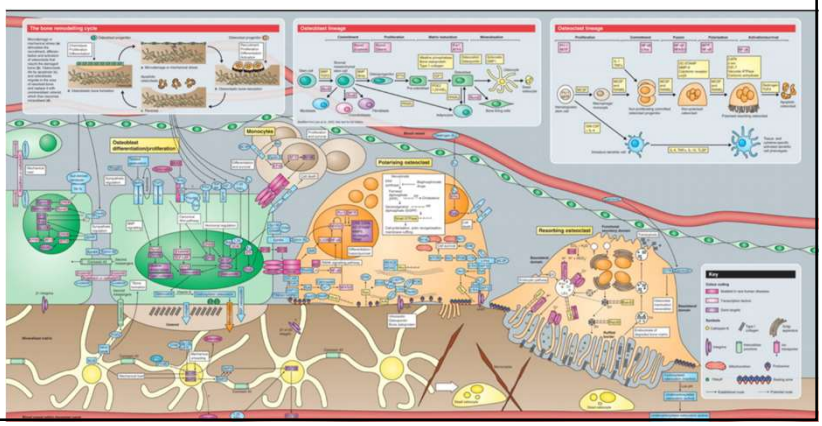
Update since 2015
3. Calcium "replacement" is complex

- Timing of intake?
  - Pre vs during
- Form of intake?
  - Gut absorption
  - Rate of change of iCa
- IV Replacement may not completely abolish PTH response
- Other minerals – Mg, P



Update since 2015
4. Acute effects vs chronic effects

- Do acute changes in bone markers reflect remodelling?
  - Not quantitative
  - Remodelling = balance between formation and breakdown over long-term
- PTH is acutely catabolic but chronically anabolic
- Does chronic Ca support around exercise promote better bone health?



Update since 2015
4. Scenarios of greatest concern

- Exercise with little bone loading effect
- High intensity exercise
- Repeated bouts of exercise with subsequent sessions occurring before return to bone “baseline”
- ?Hyponatremia
- Athletes with other risk factors for poor bone health

Pragmatic approaches are useful

Promoting intake of dairy in pre-exercise meal or snack (especially in the morning) can be useful and consistent with other health and performance messages

- An early start to the day in meeting recommended dairy serves
- Meeting goals for better protein spread over the day
- Contributor to good energy availability
- Pre-exercise fuelling

Dairy is versatile and widely accessible

Cold vs Hot

Private intake vs Social Activity

Sweet Vs Savoury

Variants

- range in carbohydrate and fat (energy) content
- serve size to suit kilojoule and financial budgets
- UHT shelf stable
- lactose free
- A2 variants

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