Consequences of Cutting Weight on Indices of Bone Metabolic Health in Elite Female Judoists

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Background

- First World Championships:
  - Males: Tokyo, 1956
    - No weight classes
  - Females: New York, 1980
    - Weight classes

- First Olympics for Female Judo:
  - Barcelona, 1980
    - Weight classes

- Consequence:
  - Change in behavior: weight cutting
Dedicated to the women who started it all …
First Studies on Judo & Bone Health

- De Crée, et al., 1991: case of osteoporosis in young female judoist
- Kayal, et al., 1993: benefits of oral contraceptives (OC) for female judoists
- Baeyens, 1994: reduce injury rate in OC takers
First Prospective Study Bone/Judo

- De Crée, et al., 1995
- 5-Week trial (1992)
- Heavy training
- Eucaloric
- Results:
  - Reduced estrogen levels
  - Increased 3-MH, OHProI, UA, MG, CPK, LDH, GOT

![Graph showing plasma concentration changes](image.png)
Meanwhile …

- Important case study information
Ulla Werbrouck vs. Heidi Rakels?
The Prize: -72 kg Olympics 1992
Rakels’ Statistics

- 5’10 (1.78m)
- Lbs. 169.5 (77 kg)
  - Generally dropped 5kg → -72 kg
- Challenge: Olympics -66kg!
The Method

- Strict diet
- Strict training regime
- Severely intense training regime
- Careful definition & monitoring using hydrostatic weighing
- Dietary supplements
- Mental strength: tunnel vision
The Result – Part 1

- In 6 weeks: -11 kg
- Initially some dehydration
- Heart Rate: down to 29 bts/min
- Loss of fat + gain LBM
- Top condition
- No injuries!
- Most important: -66kg + Olympic Ticket!
The Result – Part 2
The Results – Part 3

- Weight increase (low metabolism)
- Emotional breakdown
- Wrist fracture
- Stress fractures
- ACL
- Bone & muscle integrity ↓
Decided to Expand Earlier Study

- Purpose: Further identify effects of weight cycling on bone health
- Methods:
  - 5-Wk program: aerobic, anaerobic, resistance, & judo
  - Expanded subject group to 27 women
  - 17-29 years old (+ age-matched controls)
  - <72 kg (no heavy-weights ref. old classes)
  - No OC’s,
  - Anthropometric, cardiovascular, blood- & urinalysis
Methods (detailed):

- **Anthropometry:**
  - body mass, %IBW, body fat (5 skin folds), LBM

- **Cardiorespiratory:**
  - ECG-monitored incremental load test (cycle ergometer); VO2max (online gas analyzer)

- **Hormone analysis:**
  - follicular (FPh [day 7-10]) & luteal phase (LPh [day 23-25]) plasma estrone (E1), estra-diol (E2), progesterone (P4), LH, prolactin (Prl), & β-endorphin (β-End) by RIA

- **Blood biochemistry:**
  - lactate (Lct), uric acid (UA), creatine phosphokinase (CPK), glutamic oxalacetic transaminase (GOT), lactic dehydrogenase (LDH), myoglobin (MG), and interleukin-1 (IL-1)

- **Urinalysis:**
  - 24-hour collections for hydroxyproline to creatinine ratio (OH-Prol/Crt) [= bone breakdown], 3-methylhistidine [= muscle breakdown]

- **Experimental design:**
  - **Training:** five weeks of heavy aerobic, anaerobic, and resistance training as part of Olympic preparations; per day: 2-h weight training + 2-h competitive *randori* + 2-h judo-technical drills + ≥ either 6-km run, 8 × 200 m or 16 × 100 m interval sprint (80% intensity)
  - **Acute exercise test (submaximal & maximal):** 50 W/4-min increments, followed by 1-min relative rest after 4 min at 150 W to allow submax (±60% VO2max) blood collection, followed by 50 W/min intensity increments till volitional exhaustion
  - **Diet:** Lactovegetarian diet 2 days pre- & post-urine collection
Statistical Analysis

- **Descriptive data:**
  - Student’s two-tailed *t*-test;

- **Responses to:**
  - acute exercise via one-way ANOVA;
  - pre- vs. post-training by two-way REANOVA (group × time);
  - mean differences by post-hoc comparison using least squares
    (Δ serial blood sampling, inter-actions sampling & exercise
times);

- **Pearson’s correlation** between hormonal, biochemical &
descriptive characteristics;

- **A priori** set α= 0.05
Results:

- Increased (*P*<0.05) muscle breakdown (3-MH, 3-MH/body mass, 3-MH·10³/Clr)
- Increases in both bone breakdown and build-up
- Sharp decreases in Luteal Phase estrogens (*P*<0.01)
- In women with most significant estrogen decreases, bone breakdown outweighs bone build
- Significant increase in injuries strongly correlated to estrogen decreases and extent of weight loss
Development of Bone Injuries in Female Judoists

- **X-Ray:**
  - Typical bone-deaminarization effect seen after estrogen depletion in pre-menopausal women. Note decreased cortical thickness, and less opaque density
Discussion: Appreciation of Results

- Athlete’s view:
  - Accidental judo injuries

- Coach’s view:
  - Accidental judo injuries

- Federation’s view:
  - Accidental judo injuries

- Science’s view:
  - Dead wrong!
Figure 28.4C. Measuring body volume by underwater weighting. Prone and supine underwater weighting methods provide the same values, with residual lung volume measured before, during, or after the underwater weighting. Seated in a therapy pool, for any of the methods, subjects can use a snout fit with nose clip if they experience apprehension about submersion. The final calculation of underwater weight must account for these effects.

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What is happening?

Figure 30.21. Generalized trend for the percentage composition of the weight lost during 4 weeks of caloric restriction.

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The ‘normal’ menstrual cycle

- +/- 28 days
- Normal LH/FSH pulsatility
- Normal plasma estrogen levels
  - Luteal phase: 100-300 pg/mL
  - Peak: 200-600 pg/mL
- Ovulation
- Normal corpus luteum development
- Normal $P_4$ levels (LPh: 0.5 $\Rightarrow$ 20 ng/mL)
The ‘normal’ menstrual cycle

<table>
<thead>
<tr>
<th>Phases of the Ovarian Cycle</th>
<th>Follicular Phase</th>
<th>Luteal Phase</th>
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<tbody>
<tr>
<td>GnRH pulse frequency (pulses/day)</td>
<td><img src="image" alt="Graph" /></td>
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<tr>
<td>Gonadotropic hormone levels (U/l)</td>
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<tr>
<td>Follicular stages during the ovarian cycle</td>
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Normal Bone

- Calcium, Phosphorus, Hydroxyapatites
- Ca\(^{++}\): 1,200-1,400 mg in skeleton
- 5-7% of bone recycled/week
- Spongy bone replaced every 3-4 years

- Requires: Normal estrogens, normal diet, normal caloric intake, normal rest
Normal Muscle

- Requires normal hormones:
  - estrogens, testosterone, growth hormone, insulin, protein and … testosterone/cortisol ratio
- Requires normal diet, rest, recovery
Summary

- Consequences of High-Intensity Judo in Females:
  - Female judoists are characterized by same menstrual problems as certain other sports
  - Evidence of high muscle catabolism & bone turnover
  - Training → prevalence of menstrual irregularities, muscle catabolism & collagen turnover
Recent Literature Findings:

- Green, et al., 2007:
  - Sharp increase in judo injuries in women if weight loss >5%

- Prouteau, et al., 2005:
  - Increased C-terminal telopeptide of type-I collagen (CTX) (P<0.0001)
Awareness of Risks

- Overtraining
- Eating disorders
- Stress fractures
- Musculotendinous injuries,
- Myoglobinuria & rhabdomyolysis
- Emotional instability
- Temporary subfertility
Does this make judo unhealthy?

- No
  - Necessity of proper knowledge & understanding
- Coach’s role:
  - Awareness of risks & athlete’s condition
  - … Accountability
  - Refer to specialists in time
  - Common sense
  - Diet (calcium-rich)
  - Normal menstrual cycle; if not, contraceptive pill?
References