Adventure and adaptation:
A goal oriented journey toward resilience through stress

Bryce Carlson, PhD
Outline

• Nutrition and human evolution as a gateway to adventure and adaptation
• Race Across USA
• North Atlantic Solo Row
• Resilience and unknown unknowns
How to build a big brain...

1. Remove evolutionary constraints
2. Apply selection pressure
Constraints:

Expensive tissue hypothesis

• Metabolically expensive tissues: brain, gut, liver, kidney, heart

• Humans BMR = expectation for body size

• Trade-offs:
  for brain size to increase something has to shrink

• In humans, an increase in dietary quality (reduction in dietary fiber, increase in protein, carbohydrates, and/or fat) reduction in gut size may have released such a constraint

• Increase in nutritional quality may have facilitated reduction in gut size

Aiello and Wheeler 1995 *Curr Anth*
Selection pressure

Ecological intelligence hypothesis

greater cognition required to forage or hunt for hard-to-find and process foods

• Clumped food resources (e.g. fruit and hunted animals) require a cognitive map
• Know which species are edible, where to find fruit, remember which sites have been visited
• Foods that are hard to access or process require extractive techniques
• Higher quality foods seasonally distributed across a landscape requiring greater processing may have driven pressure for greater cognition

Photo: smithsonianmag.com
Goal-oriented adaptation vs. natural selection

- Superior Sawtooth 100 mile
- Midwest Ultra Grand Slam
  - Kettle Moraine 100 mile
  - Mohican 100 mile
  - Burning River 100 mile
  - Hallucination 100 mile
- Spartathlon (155 miles)
  - Athens to Sparta, Greece
Can we study the role of nutrition in processes of adaptation via living populations undergoing stress?

Ultra-endurance athletes routinely explore and seek to defy/expand human physiological and psychological limitations
STRESS

acclimation
acclimatization
evolution

ADAPTATION

NUTRITION
TECHNOLOGY
BEHAVIOR

+ NUTRITION
TECHNOLOGY
BEHAVIOR
Race Across USA

• 3100 mile footrace
• ~26.2 mile stages
• January 16 – June 2, 2015

• 12 runners, 3 assistants
• Runner + Research Director

• Energetics*, cardiovascular*, biomechanics*, nutrition, microbiome, epigenetics, psychology

Photo: raceacrossusa.org
Preparing to run

Anticipated challenges:
• Volume of activity
• Impact of road running
• Intensity of racing
• Heat stress
• Nutrition (fuel + recovery)

Unanticipated challenges:
TBD
On the **run**

**Baseline data collected at UCLA**
- Doubly labeled H$_2$O
- Blood samples
- Heart scans
- Running biomechanics
- Stool samples
- Weight, body fat %
- Psychological survey

*Follow-up data collected en route*
Manifestations of stress

**Weeks 1-2**
*Embodiment of stress*
- Inflammation
- Joint pain
- Blisters

**Weeks 3-4**
*Routine building*
- Physical adaptation well underway
- Mentally adapting to routine
Sustained high levels of physical activity lead to improved performance among “Race Across the USA” athletes

Cara Ocobock 1 • Aaron Overbeck 2 • Clare Carlson 2 • Chris Royer 2 • Alexander Mervenne 2 • Caitlin Thurber 3 • Lara R. Dugas 4 • Bryce Carlson 5 • Herman Pontzer 3, 6

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Abstract
Objective: To investigate physiological and performance adaptations associated with extremely high daily sustained physical activity levels, we followed six runners participating in the 2015 Race Across the USA. Participants completed over 42.2 km a day for 140 days, covering nearly 5,000 km. This analysis examines the improvement in running speed and potential adaptation in mean submaximal heart rate (SHR) throughout the race.

Methods: Data were collected during three 1-week long periods corresponding to the race beginning, middle, and end and included heart rates (HRs), body mass, running distances and speeds. HR data were collected using ActiTrainer HR monitors. Running speeds and distances were also recorded throughout the entire race.

Results: Athletes ran significantly faster as the race progressed (p < .001), reducing their mean marathon time by over 4 h. Observed mean SHR during the middle of the race was significantly lower than at the beginning (p = .003); however, there was no significant difference between mean SHR at the middle and end of the race (p = .998).

Conclusion: These results indicate an early training effect in SHR during the first half of the race, which suggests that other physiological and biomechanical mechanisms were responsible for the continued improvement in running speed and adaptation to the high levels of sustained physical activity.

Keywords
endurance exercise, submaximal heart rate, training adaptation
FIGURE 1  Mean monthly speed for each participating runner. Overall, subjects increased running speed throughout the race. RALUSA 4 and 6 decreased running speeds from the middle to the end of the race.

FIGURE 2  Mean monthly speed and mean SHR rates for each participating runner. Overall, subjects increased running speed throughout the race while mean SHR significantly decreased from the beginning to the middle of the race. Mean SHR did not significantly change from the middle of the race to the end.
Extreme events reveal an alimentary limit on sustained maximal human energy expenditure

Caitlin Thurber¹, Lara R. Dugas², Cara Ocobock², Bryce Carlson⁵, John R. Speakman⁴, Herman Pontzer⁵,⁶,⁷

The limits on maximum sustained energy expenditure are unclear but are of interest because they constrain reproduction, thermoregulation, and physical activity. Here, we show that sustained expenditure in humans, measured as maximum sustained metabolic scope (SusMS), is a function of event duration. We compiled measurements of total energy expenditure (TEE) and basal metabolic rate (BMR) from human endurance events and added new data from adults running ~250 km/week for 20 weeks in a transcontinental race. For events lasting 0.5 to 250+ days, SusMS decreases curvilinearly with event duration, plateauing below 3x BMR. This relationship differs from that of shorter events (e.g., marathons). Incorporating data from overfeeding studies, we find evidence for an alimentary energy supply limit in humans of ~2.5x BMR; greater expenditure requires drawing down the body’s energy stores. Transcontinental race data suggest that humans can partially reduce TEE during long events to extend endurance.
Thurber et al. 2019 Science Advances
Personal lessons:
Stress can be positive
Personal lessons:

*Perception is malleable*
Personal lessons:

We absorb the energy around us
Personal lessons:

Fixating on variables we can’t control prevents us from adapting to them.
Preparing to row

Anticipated challenges:
• Volume of activity
• Psychology of isolation
• Safety
• Navigation
• Permits, customs
• Funding

Unanticipated challenges:
TBD
Psychological inventory

*Complete daily, responding for previous 24 hours*

**Quantitative**
0 = least/never/not, 10 = most/always

- Rating of perceived exertion
- Worst pain
- Average pain
- Pain interference
- Fatigue
- Fatigue interference
- Sleepiness
- Restfulness
- Positive emotions
- Calmness
- Confidence
- Loneliness
- Boredom
- Anxious
- Frustration

**Qualitative**
3 open-ended questions to inspire reflection on the past 24 hour experience
Primary desalinator

Computer

Centerboard, autopilot

Nav. electronics

AIS

Secondary GPS

Monitors

Music

Primary GPS

Stereo

Hurricane Chris

[Image of a map with various navigation and music equipment labels]
ORIGINAL RESEARCH

The Physical and Psychological Experience of Rowing the North Atlantic Solo and Unassisted

Kevin N. Alscher, PhD; Daniel Whisbey, PhD; Nicole M. Alberts, PhD;
Makenna Kaylor, BS; Anna L. Kraz, PhD

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<table>
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<th>Mean</th>
<th>SD</th>
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<th>Maximum</th>
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<td>Pain interference</td>
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<td>2.3</td>
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<td>Restfulness</td>
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<td>2.7</td>
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</tbody>
</table>

Perceived exertion is scored 6 (no exertion) to 20 (maximal exertion); all other variables are 0 (least/some/not at all) to 10 (most/always).
Personal lessons

• “Crazy” is subjective
• The strength we seek is layered within and the number of layers is infinite
• Technology can buffer isolation, to an extent
• Logic and vigilance > emotion

Survival necessitated focus on variables under my control, and maintenance of near constant vigilance. After the finish, it seemed to take a few days to “feel” again.
As we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns—the ones we don’t know we don’t know.

Donald Rumsfeld
February 12, 2002
Known knowns

Anticipated challenges that we are currently prepared for

Known unknowns

Anticipated challenges that we are currently unprepared for

- May require new knowledge, skills, credentials, fitness, etc.
- Can work systematically to prepare for these challenges
- Cycles of mild to moderate stress + recovery (i.e. training)
- Transforming oneself into the kind of person capable of meeting these challenges, and thereby move them into the previous category of known knowns.
Unknown unknowns

Unanticipated challenges that we are unprepared for

• These are trickier – how to prepare?
• Require active problem solving skills and resilience
• Problem solving and resilience are built from experience
• Tool kit of skills necessary to remain calm, focused, and active in the face of novel stressors
• RAUSA and N. Atlantic Solo Row
Identifying knowns from unknowns

• Requires self awareness and **metacognitive sensitivity**
• An ability to accurately assess one’s abilities, and the gap between current knowledge/skills/fitness and what will be required for the challenge ahead
• Necessary to prepare for the challenges one might conceivably anticipate are coming

But once you’ve prepared for known unknowns, **resilience** is key to successfully navigating stress. And resilience may be a function of non-specific stress-adaptation experiences.
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