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How Mealvana Calculates Your Fueling: The Science Behind Your Personalized Nutrition Plan

Ever wondered why Mealvana recommends 75 grams of carbs per hour for your long bike ride but only 55 for your tempo run? Or why your sodium targets are different from your training partner's? Let's pull back the curtain on the sports science that powers your personalized fueling recommendations.

The Short Version

Your fueling needs aren't one-size-fits-all. They depend on:

- **How long** you're exercising
- **How hard** you're working
- **What sport** you're doing (bike vs. run vs. swim)
- **Your body** (sweat rate, gut tolerance, weight)
- **The conditions** (heat, humidity, altitude)

Mealvana combines decades of peer-reviewed sports nutrition research with your personal profile to generate recommendations tailored specifically to you. Here's how it all works.

Part 1: Carbohydrates — Your Engine's Fuel

Why Carbs Matter

During endurance exercise, your muscles burn a mix of carbohydrates and fat. The harder you go, the more you rely on carbs. A 2.5-hour workout at moderate-to-hard intensity can burn through 300-500 grams of stored carbohydrate (glycogen) — and your body can only store about 400-500 grams total (Coyle, 2004).

The math is simple: If you don't replace carbs during long or hard efforts, you'll bonk.

The 60 g/hr Ceiling (And How to Break It)

Here's something fascinating that researchers discovered: **your gut can only absorb about 60 grams of a single type of carbohydrate per hour**, no matter how much you consume.

This finding has been replicated across dozens of studies. As Dr. Asker Jeukendrup summarized in his landmark 2004 review: *"A single CHO ingested during exercise will be*

oxidized at rates up to about 1 g/min, even when large amounts of CHO are ingested" (Jeukendrup, 2004, *Nutrition*).

Why? It comes down to intestinal transporters — specialized proteins that shuttle sugar from your gut into your bloodstream. The main transporter for glucose (called SGLT1) maxes out at roughly 1 gram per minute (Jeukendrup & Jentjens, 2000, *Sports Medicine*).

But here's the game-changer: Fructose uses a *different* transporter (GLUT5). By combining glucose and fructose, you can essentially open a second absorption lane.

Carb Source	Max Absorption Rate	Research
Glucose only	~60 g/hr	Jeukendrup, 2004
Glucose + Fructose	90-105 g/hr	Jentjens & Jeukendrup, 2005
Trained gut + optimal ratio	Up to 120 g/hr	Hearris et al., 2022

This is why most sports nutrition products now use glucose:fructose blends (often listed as maltodextrin + fructose). The research from Jentjens & Jeukendrup (2005) showed that athletes can oxidize up to **105 g/hr** with the right carb mix — representing a 75% increase over single-source carbohydrate (Jentjens & Jeukendrup, 2005, *British Journal of Nutrition*).

More recent work has pushed this further. Hearris and colleagues (2022) demonstrated that **120 g/hr is practically tolerable** for athletes with trained guts using an optimized 1:0.8 glucose:fructose ratio (Hearris et al., 2022).

The Optimal Carbohydrate Ratio

Not all glucose:fructose ratios are equal. The research has evolved:

- **2:1 ratio (glucose:fructose):** Optimal for intakes up to 90 g/hr (Jeukendrup, 2008, *European Journal of Sport Science*)
- **1:0.8 ratio:** Better for intakes of 90-120 g/hr, with improved GI comfort (Rowlands et al., 2015)

This ratio matters because fructose absorption can become the bottleneck at very high intake rates. Elite marathon runner Eliud Kipchoge reportedly uses a 1:0.8 ratio for his record attempts.

How Mealvana Calculates Your Carb Targets

We use duration and intensity as the primary drivers, following the evidence-based guidelines from the American College of Sports Medicine and International Olympic Committee consensus statements (Thomas et al., 2016, *Journal of the Academy of Nutrition and Dietetics*):

Base Recommendations by Duration:

Workout Duration	Carb Target	Scientific Rationale
Under 60 min	0-30 g total	Glycogen stores sufficient; mouth rinse approach may help (Carter et al., 2004)
60-90 min	30-60 g/hr	Maintains blood glucose (Burke et al., 2011)
90 min - 2.5 hr	45-60 g/hr	Delays glycogen depletion
2.5 - 4 hr	60-90 g/hr	Requires multiple transportable carbs (Jeukendrup, 2014)
4+ hr	80-100+ g/hr	Maximum sustainable; must include real food (Pfeiffer et al., 2012)

Sources: Burke et al., 2011, Journal of Sports Sciences; Jeukendrup, 2014, Sports Medicine; Thomas et al., 2016

Your Personal Modifier:

In your Mealvana profile, you set your **maximum carb tolerance** — the most you can comfortably consume per hour without GI distress. We never recommend above this ceiling, even if the workout duration would otherwise call for it.

Research confirms this individual variation is real: a large field study of Ironman competitors found carbohydrate intake ranged from **6 to 136 g/hr** across athletes, with higher intakes correlating to faster finish times (Pfeiffer et al., 2012, *Medicine and Science in Sports and Exercise*).

Example: If you've set your tolerance at 70 g/hr and you're doing a 4-hour ride, we'll recommend 70 g/hr (your max), not the 80-90 g/hr that duration might otherwise suggest.

Part 2: Pre-Workout Nutrition — Setting Up for Success

What you eat *before* your workout matters as much as what you consume during it. But the optimal pre-workout meal depends on timing, sport type, and workout intensity. Here's how Mealvana calculates your pre-workout recommendations.

The Science of Pre-Exercise Fueling

Your pre-workout nutrition serves three purposes:

1. **Top off liver glycogen** — Depleted overnight, liver glycogen fuels your brain and maintains blood glucose (Casey et al., 2000)
2. **Ensure adequate muscle glycogen** — Your primary fuel for moderate-to-high intensity work (Hawley & Burke, 2010)
3. **Optimize hydration status** — Start euhydrated, not playing catch-up (Sawka et al., 2007)

The challenge: eat enough to fuel performance, but not so much (or so close to exercise) that GI distress derails your workout.

Timing Windows: How Time Before Exercise Changes Everything

Research has established clear timing-based guidelines. The closer you get to your workout, the simpler and smaller your nutrition should be (Kerksick et al., 2017, *Journal of the International Society of Sports Nutrition*).

3-4 Hours Before: The Full Meal Window

Nutrient	Target	Rationale
Carbohydrate	1-4 g/kg body weight	Tops off glycogen stores (Burke et al., 2011)
Protein	0.15-0.25 g/kg	Supports muscle protein balance (Kerksick et al., 2017)
Fat	0.3-0.5 g/kg	Acceptable; adequate digestion time
Fiber	Moderate	Can include vegetables, whole grains

Example for 70kg athlete: 70-280g carbs, 10-18g protein, 20-35g fat

This is your window for a "real meal" — oatmeal with banana and eggs, a bagel with peanut butter, rice with chicken and vegetables. The 3-4 hour buffer allows complete gastric emptying before exercise begins (Rehrer et al., 1992).

1-2 Hours Before: The Snack Window

Nutrient	Target	Rationale
Carbohydrate	1-2 g/kg body weight	Maintain blood glucose (Ormsbee et al., 2014)
Protein	0-10g	Optional; keep minimal
Fat	<10g	Slows gastric emptying; minimize (Rehrer et al., 1992)
Fiber	Low	Avoid GI bulk

Example for 70kg athlete: 70-140g carbs, minimal fat/protein

This is your window for easily digestible carbs — white bread with jam, a banana, rice cakes, a small bowl of cereal with low-fat milk. Fat and fiber should be minimized as they slow gastric emptying and increase GI distress risk.

30-60 Minutes Before: The Top-Up Window

Nutrient	Target	Rationale
Carbohydrate	0.5-1 g/kg	Final glucose availability boost (Jeukendrup & Killer, 2010)
Protein	0g	No time to digest
Fat	0g	No time to digest
Fiber	0g	Risk of GI distress

Example for 70kg athlete: 35-70g carbs from simple sources

This window is for simple, fast-digesting carbs only — a gel, sports drink, white bread with honey, or a ripe banana. Research shows that consuming carbohydrate in this window can

enhance performance, particularly for sessions starting with low glycogen or lasting >60 minutes (Jeukendrup & Killer, 2010, *Annals of Nutrition and Metabolism*).

<30 Minutes Before: Proceed with Caution

Eating within 30 minutes of exercise is generally not recommended for most athletes. However, for early morning workouts where eating 2-3 hours prior isn't practical, a small amount of easily digestible carbohydrate (15-30g) is better than training completely fasted for high-intensity or long sessions (Rothschild et al., 2020, *Nutrients*).

Sport-Specific Pre-Workout Guidelines

Your gut doesn't respond the same way to cycling, running, and swimming. The mechanical and physiological demands of each sport create different tolerance windows.

Running: The Most Sensitive

Running creates the most GI stress due to:
- Vertical oscillation and impact with each stride
- Increased intra-abdominal pressure
- Greater blood flow diversion from the gut compared to cycling at similar intensity

Research consistently shows runners experience more GI symptoms than cyclists (Peters et al., 1999). A survey of 606 Dutch endurance athletes found that *"approximately 45% of runners reported GI problems during running, compared to 33% of cyclists"* (de Oliveira & Burini, 2009, *British Journal of Sports Medicine*).

Mealvana's Running Pre-Workout Adjustments:

Factor	Adjustment
Last full meal	3-4 hours minimum before hard runs
Carb amount (1-2hr window)	Lower end of range (1-1.5 g/kg)
Fat tolerance	<10g in final 2 hours
Fiber tolerance	Very low; avoid high-fiber foods day-of
High-intensity runs	Extend digestion window by 30-60 min

Cycling: The Most Forgiving

Cyclists can generally tolerate more food, closer to exercise:
- Stable torso position minimizes GI jostling
- Aerodynamic posture doesn't compress stomach
- Lower relative blood flow diversion at equivalent heart rate

Studies show cyclists tolerate higher carbohydrate intake during exercise, and this tolerance extends to pre-exercise nutrition (Pfeiffer et al., 2012).

Mealvana's Cycling Pre-Workout Adjustments:

Factor	Adjustment
Last full meal	2-3 hours acceptable for most
Carb amount (1-2hr window)	Full range acceptable (1-2 g/kg)
Fat tolerance	Moderate amounts okay 2+ hours out
Fiber tolerance	Moderate; more forgiving than running
Indoor trainer	Same as outdoor; if anything, slightly more conservative due to heat

Swimming: Unique Considerations

Swimming presents different challenges:
- Horizontal body position affects gastric emptying
- Water pressure on the abdomen
- Breathing pattern interruptions
- Cold water can slow digestion

Research on swimming-specific pre-exercise nutrition is limited, but expert consensus suggests moderate caution. The triathlon-specific research from Jeukendrup et al. (2005) notes that *"gastric emptying may be impaired by the change in body position"* when transitioning between disciplines (Jeukendrup et al., 2005).

Mealvana's Swimming Pre-Workout Adjustments:

Factor	Adjustment
Last full meal	2-3 hours minimum
Carb amount (1-2hr window)	Moderate (1-1.5 g/kg); avoid large volumes
Fat tolerance	Low; horizontal position slows fat digestion
Fiber tolerance	Low to moderate
Open water	Allow extra time; cold water + nerves affect gut
Pool sessions	Slightly more forgiving than open water

Intensity Matters: Hard Sessions Need More Buffer

Exercise intensity directly affects gastrointestinal function. Higher intensity means:
- Greater blood flow diversion to working muscles
- Reduced splanchnic (gut) blood flow — up to 80% reduction at maximal exercise (van Wijck et al., 2012)
- Slower gastric emptying
- Increased GI symptom risk

A systematic review found that *"exercise intensity is considered one of the most important factors determining gastrointestinal disturbance during exercise"* (de Oliveira et al., 2014, *Sports Medicine*).

Mealvana's Intensity-Based Adjustments:

Workout Intensity	Pre-Workout Window	Carb Target	Fat/Fiber Tolerance
Recovery/Easy (Z1-Z2)	1-2 hours okay	0.5-1 g/kg	Moderate
Endurance (Z2-Z3)	2-3 hours preferred	1-2 g/kg	Low-moderate
Tempo/Threshold (Z3-Z4)	3+ hours for full meal	1-2 g/kg	Low
Intervals/VO2max (Z4-Z5)	3-4 hours for full meal	1.5-2 g/kg	Very low
Race/key workout effort	3-4 hours minimum	2-4 g/kg	Minimal

The Early Morning Workout Problem

Many athletes train at 5 or 6 AM. Waking at 2 AM to eat isn't realistic. What does the research say?

Option 1: Train Fasted (Strategic Use)

Fasted training — exercising after an overnight fast without pre-workout food — has become popular for its potential metabolic benefits. But it's not appropriate for every workout.

The Science: What Fasted Training Does

A 2016 meta-analysis found that aerobic exercise performed fasted induces significantly higher fat oxidation than exercise performed fed (Vieira et al., 2016, *British Journal of Nutrition*). The mechanism: without incoming carbohydrate, insulin levels remain low, allowing greater mobilization of fatty acids for fuel.

Research from Van Proeyen et al. (2011) demonstrated that 6 weeks of fasted training enhanced markers of fat metabolism, including increased fatty acid binding protein (FABPm) content and reduced glycogen breakdown during exercise (Van Proeyen et al., 2011).

However, there's a critical caveat from Dr. Daniel Moore's research at the University of Toronto: **training with low carbohydrate availability increases protein requirements**. In a carefully controlled study, Gillen, Moore and colleagues found that endurance exercise performed in a low-carbohydrate state resulted in significantly higher amino acid oxidation during recovery, suggesting a greater protein requirement to support whole-body protein synthesis (Gillen et al., 2019, *Medicine & Science in Sports & Exercise*).

"It is important to increase your protein intake if you are training with low-carbohydrate availability as the extra amino acids that are used as energy must be replaced through the diet." — Dr. Daniel Moore, University of Toronto

Which Workouts Are Suitable for Fasted Training?

Not all workouts respond equally to fasted training. Here's a research-backed breakdown:

Workout Type	Fasted Suitability	Rationale
Easy/Recovery runs (Z1-Z2)	✓ Good candidate	Low glycogen demand, enhances fat adaptation
Moderate steady-state (Z2-Z3, <75 min)	✓ Acceptable	Sustainable intensity, manageable glycogen needs

Workout Type	Fasted Suitability	Rationale
Long runs (>90 min)	× Not recommended	Performance suffers, muscle breakdown increases
Tempo/Threshold (Z3-Z4)	× Not recommended	Quality suffers without carbs; train these fueled
Intervals/VO2max (Z4-Z5)	× Avoid	Glycolytic work requires glycogen; dangerous to perform depleted
Easy cycling (Z1-Z2)	✓ Good candidate	Stable, low-impact; excellent for fat adaptation
Moderate cycling (<90 min)	✓ Acceptable	Can sustain reasonable power fasted
High-intensity cycling	× Not recommended	Sprint/interval work impaired without glycogen
Swimming	✓ Generally suitable	Lower sweat rate, stable intensity, pool environment

Duration Guidelines for Fasted Training:

Duration	Fasted Suitability	Notes
<45 min	✓ Excellent	Minimal glycogen depletion, low risk
45-60 min	✓ Good	Most athletes tolerate well
60-75 min	~ Marginal	Individual tolerance varies; stay Z1-Z2
75-90 min	× Risky	Performance decline likely; fuel if quality matters
>90 min	× Not recommended	Significant muscle breakdown, cortisol elevation

A comprehensive review concluded: *"We recommend that endurance athletes should avoid high intensity training while fasting"* (Alghannam et al., 2020, *Open Access Journal of Sports Medicine*).

Sport-Specific Fasted Training Considerations:

Running:
- Most suitable for easy/recovery runs under 60 minutes
- GI system actually benefits from fasted training (no sloshing)
- Higher muscle damage risk than cycling — prioritize post-workout protein
- Avoid fasted running for any session where pace/quality matters

Cycling:
- Generally more tolerant of fasted training than running
- Can extend duration slightly (up to 75 min easy) due to no impact stress
- Indoor trainer sessions work well fasted (controlled environment)
- Avoid fasted cycling for any interval or tempo work

Swimming:
- Well-suited for fasted training

- Lower sweat rate reduces electrolyte concerns
- Controlled environment; can exit pool if needed
- Most pool sessions under 60 min work well fasted

The "Fuel for the Work Required" Framework: James Morton's Approach

The most sophisticated approach to carbohydrate periodization comes from Professor James Morton (Liverpool John Moores University, former Head of Nutrition for Team Sky/INEOS Grenadiers) and colleagues. Their landmark 2018 paper introduced the **"Fuel for the Work Required"** paradigm and **Glycogen Threshold Hypothesis** — the scientific framework that powered Chris Froome's famous race-winning attacks (Impey, Morton et al., 2018, *Sports Medicine*).

The Core Principle:

Rather than chronic low-carb diets OR always eating high-carb, Morton's framework adjusts carbohydrate availability **day-to-day and meal-by-meal** according to the demands of each specific training session:

- **High-intensity/key sessions →** High carb availability (fuel the quality)
- **Low-intensity/easy sessions →** Low carb availability (enhance adaptation)
- **Competition →** Always fully fueled

"CHO availability should be adjusted in accordance with the demands of the upcoming training session(s)... creating a metabolic milieu conducive to facilitating the endurance phenotype." — Impey, Morton et al., 2018

The Glycogen Threshold Hypothesis

Morton's research identified a critical glycogen "sweet spot" for training adaptations:

Muscle Glycogen Level	Training Outcome
>500 mmol/kg dry wt	Adaptations blunted; gene expression suppressed
300-500 mmol/kg dry wt	Good zone for quality training
200-300 mmol/kg dry wt	**Optimal adaptation zone** — enhanced cell signaling, gene expression
<200 mmol/kg dry wt	Training intensity impaired; potential harm

The key insight: **Start low enough to trigger adaptation, but not so low you can't complete the work.**

Their systematic review found that when training sessions were commenced with glycogen ≤300 mmol/kg dry weight:
- 73% of studies showed augmented cell signaling
- 75% showed enhanced gene expression
- 78% showed increased oxidative enzyme activity

Practical "Train Low" Models from Morton's Research:

Model	How It Works	Best For
Fasted training	Morning session after overnight fast	Easy aerobic sessions <75 min
Twice-daily training	Second session done glycogen-depleted	Doubling up easy + moderate sessions
Sleep low, train low	Evening HIT → skip carbs → morning easy session	Maximizing adaptation window
Post-exercise CHO restriction	Delay carbs 3-4 hours after training	Recovery sessions, easy days

The "Sleep Low, Train Low" Protocol in Detail

This specific model combines Morton's framework with practical application:

The Protocol:
1. **Evening:** Perform a high-intensity session (intervals, tempo) with full carb availability
2. **Post-workout:** Skip or minimize carbs until the next morning (extend the low-glycogen window)
3. **Morning:** Perform an easy/moderate session fasted (muscle glycogen already depleted from evening)
4. **Post-morning session:** Resume normal carbohydrate intake

Marquet et al. (2016) found that trained triathletes using this "sleep low" strategy for 3 weeks improved 10-km running performance by 2.9%, improved cycling efficiency by 11.7%, and reduced body fat by 1.1% compared to athletes consuming the same total carbohydrates distributed evenly throughout the day (Marquet et al., 2016, *Medicine & Science in Sports & Exercise*).

What Proportion of Training Should Be "Train Low"?

Morton's research suggests **30-50% of training sessions** can be performed with reduced carbohydrate availability — not all of them. The remaining 50-70% should be fully fueled to:
- Support high-quality interval/threshold work
- Prevent chronic energy deficiency
- Maintain immune function
- Support bone health (emerging research suggests this is carb-dependent)

Putting It Together: A Sample Week

Day	Session	CHO Strategy
Mon	Easy run 45min	Train low (fasted or post-exercise restriction)
Tue	Intervals 60min	**Train high** — full carb availability
Wed	Easy bike 60min	Train low (fasted)
Thu	Tempo run 50min	**Train high** — full carb availability
Fri	Recovery swim 30min	Train low (fasted)

Day	Session	CHO Strategy
Sat	Long run 2hr	**Train high** — carbs before + during
Sun	Rest	Normal eating

In this example: 3 sessions train-low (43%), 3 sessions train-high (43%), 1 rest day

Mealvana's Implementation of "Fuel for the Work Required":

Mealvana applies Morton's framework automatically by analyzing each workout:

If Your Workout Is...	Mealvana Suggests...
Easy run, <60 min, Z1-Z2	✓ Fasted/train-low option available
Easy bike, <75 min, Z1-Z2	✓ Fasted/train-low option available
Any swim <60 min	✓ Fasted/train-low option available
Any workout with intervals	× Fuel this session (train high)
Any tempo/threshold work	× Fuel this session (train high)
Any session >75 min	× Fuel this session (train high)
Back-to-back day (fatigued)	× Fuel this session
Key workout or race simulation	× Fuel this session (train high)
Competition/race	× **Always fully fueled**

Critical: If You Train Low, Increase Post-Workout Protein

Based on Dr. Daniel Moore's research, athletes who train with low carbohydrate availability should increase their post-workout protein intake to compensate for increased amino acid oxidation during the session:

Post-Workout Context	Protein Target	Timing
Standard recommendation	0.25-0.3 g/kg	Within 1-2 hours
After train-low session	**0.35-0.4 g/kg**	**Within 30-60 min**

Example for 70kg athlete: Standard post-workout = 18-21g protein; After train-low = 25-28g protein

Notably, consuming ~20g of protein before/during a train-low session can preserve the metabolic benefits while protecting muscle protein synthesis (Impey et al., 2016).

Option 2: Strategic Small Feeding (Best of Both Worlds)

If you want to avoid true fasted training but can't eat a full meal, research supports consuming a small amount of easily digestible carbohydrate (25-50g) 15-30 minutes before exercise (Jeukendrup & Killer, 2010). This provides enough glucose to support quality work without requiring early wake-up.

Examples:
- Half a banana (~15g carbs)
- 200ml sports drink (~25g carbs)
- 1 gel (25g carbs)
- 1-2 medjool dates (~30g carbs)
- Small handful of dried fruit

Option 3: Evening Carb Loading

For planned early morning key sessions, consuming extra carbohydrate the evening before can partially compensate for the abbreviated morning window. This doesn't fully replace pre-exercise fueling but helps ensure adequate glycogen stores (Burke et al., 2011).

Mealvana generates multiple protocols for early morning workouts:
1. A "fasted training" option for suitable easy sessions (with elevated post-workout protein)
2. A minimal "wake and go" option with simple carbs only
3. An evening-before carb emphasis to compensate for morning limitations
4. A recommendation on which protocol best fits the specific workout

Pre-Workout Hydration and Sodium: Start Ahead

Hydration status at the start of exercise significantly impacts performance and thermoregulation. Starting even slightly dehydrated (2% body mass deficit) can impair endurance performance by 5-10% (Cheuvront & Kenefick, 2014, *Comprehensive Physiology*).

The ACSM recommends:

"Prehydrating with beverages, if needed, should be initiated at least several hours before the exercise task to enable fluid absorption and allow urine output to return to normal levels" (Sawka et al., 2007).

Practical Pre-Workout Hydration Guidelines:

Timing	Fluid Target	Sodium Target	Notes
2-4 hours before	5-7 ml/kg (~350-500ml for 70kg)	300-600mg	Allows time for absorption and urination
1-2 hours before	3-5 ml/kg (~200-350ml for 70kg)	200-400mg	Sip gradually, don't chug
10-20 min before	200-300ml	100-200mg	Final top-up

Why Sodium Matters Pre-Workout

Plain water is poorly retained by the body — much of it ends up as urine before you even start exercising. Adding sodium dramatically improves fluid retention.

Research by Sims et al. (2007) demonstrated that consuming a high-sodium beverage (164 mmol/L, or ~3,800 mg/L) before exercise in the heat expanded plasma volume and improved cycling time trial performance by 3% compared to a low-sodium placebo (Sims et al., 2007, *Medicine and Science in Sports and Exercise*).

The mechanism: Sodium increases plasma osmolality, which:
1. Triggers greater fluid retention (less urination)
2. Expands blood plasma volume
3. Provides a larger "reservoir" to draw from during exercise
4. Delays the point at which dehydration impairs performance

Pre-Workout Sodium Loading Protocols:

Scenario	Sodium Target	Timing	Research
Standard workout	300-600mg total	2-4 hours before	Shirreffs & Sawka, 2011
Hot conditions (>25°C)	10-25 mg/kg body weight	2-3 hours before	Sims et al., 2007
Known heavy sweater	500-1000mg total	2-4 hours before	Baker & Jeukendrup, 2014
Long race (>3 hours)	10-20 mg/kg body weight	With pre-race meal	McCubbin et al., 2020

Example for 70kg athlete in hot conditions: 700-1,750mg sodium in the 2-3 hours before exercise

Practical Sodium Sources:

Source	Approximate Sodium
1 tablet (e.g., SaltStick)	215mg
500ml sports drink	250-500mg
1 tsp table salt	2,300mg
Bouillon cube in water	800-1,000mg
Salted pretzels (30g)	400-500mg
Pickle juice (60ml)	400-500mg

Sport-Specific Pre-Workout Hydration

Running

Runners need to balance hydration with avoiding the "sloshing stomach" sensation. Excess fluid before running can cause GI discomfort due to the mechanical bouncing.

Factor	Recommendation
Total fluid 2-4hr before	5-7 ml/kg (standard)
Final hour before	Minimize — small sips only
Sodium strategy	Include with earlier fluids, not last-minute

Factor	Recommendation
Urine check	Pale yellow before starting

Cycling

Cyclists can generally tolerate more pre-workout fluid without GI issues. The stable position makes pre-hydration easier.

Factor	Recommendation
Total fluid 2-4hr before	5-7 ml/kg (full range)
Final hour before	3-5 ml/kg acceptable
Sodium strategy	Can continue closer to start
Indoor trainer	Increase by 20-30% (heat consideration)

Swimming

Swimmers have unique considerations: pool access to fluids during the session is limited, and the sensation of thirst is blunted in water.

Factor	Recommendation
Total fluid 2-4hr before	5-7 ml/kg
Final 30 min before	Moderate — won't have access during
Sodium strategy	Standard; less critical due to lower sweat rate
Open water	More aggressive pre-hydration; no during-swim access

Environmental Adjustments to Pre-Workout Hydration

Conditions matter enormously. A humid summer morning requires different preparation than a cool fall day.

Condition	Fluid Adjustment	Sodium Adjustment	Rationale
Hot (>25°C / 77°F)	+25-30%	+50-100% (sodium loading)	Higher sweat losses anticipated
Humid (>70%)	+20%	+25-50%	Sweat evaporation impaired
Cold (<10°C / 50°F)	Standard to -10%	Standard	Reduced but not eliminated sweat
Altitude (>2000m)	+15-25%	Standard	Increased respiratory water loss
Indoor (no airflow)	+20-30%	+25-50%	Dramatically higher sweat rate

Signs You've Pre-Hydrated Correctly

Good signs:

- Urine is pale yellow (not clear, not dark)
- You urinate 1-2 times in the 2 hours before exercise

- No sensation of bloating or stomach fullness at start
- Body weight is stable or slightly up from baseline

Warning signs of over-hydration:
- Urine is completely clear
- Frequent urination (>3 times in final 2 hours)
- Bloated, heavy feeling
- GI sloshing during warm-up

Warning signs of under-hydration:
- Dark yellow or amber urine
- No urination in 3+ hours
- Thirst sensation before starting
- Elevated morning heart rate

Mealvana's Pre-Workout Hydration Logic

When generating your pre-workout fluid and sodium targets, Mealvana considers:

1. **Workout duration** → Longer sessions justify more aggressive pre-hydration
2. **Your sweat rate profile** → Heavy sweaters get higher targets
3. **Environmental conditions** → Heat/humidity triggers sodium loading protocol
4. **Sport type** → Running gets more conservative final-hour guidance
5. **Time of day** → Morning workouts may need to compensate for overnight dehydration
6. **Your sodium loss rate** → Salty sweaters get higher sodium targets

Summary: Mealvana's Pre-Workout Decision Tree

When generating your pre-workout recommendations, Mealvana considers:

1. **How long until your workout?** → Sets the macro composition and total volume
2. **What sport?** → Running gets most conservative; cycling most forgiving
3. **What intensity?** → Higher intensity = longer digestion window needed
4. **What's your GI history?** → Sensitive athletes get extended windows and reduced volumes
5. **Is it early morning?** → Generates fasted protocol + evening-before option
6. **How long is the session?** → Longer sessions justify more aggressive pre-fueling
7. **What are the conditions?** → Heat/humidity triggers sodium loading protocol
8. **What's your sweat profile?** → Heavy/salty sweaters get adjusted fluid and sodium targets

The result: a pre-workout nutrition plan calibrated to your specific workout, not generic advice that ignores the difference between an easy spin and a VO2max session.

Part 3: Why Bike and Run Fueling Are Different

This is one of the most important concepts in triathlon and multisport nutrition: **you can fuel more aggressively on the bike than on the run.**

The Science

When you run, three things work against your gut:

1. **Mechanical jostling** — Every footstrike sends a shockwave through your GI system
2. **Reduced blood flow** — Running diverts more blood away from your digestive system than cycling at equivalent effort
3. **Body position** — The upright running posture affects gastric emptying differently than cycling's forward lean

These aren't just theoretical concerns. In a study of gastrointestinal symptoms across different sports, Peters et al. (1999) found that *"symptoms are more common in runners than in cyclists"* — with mechanical impact identified as a primary cause (Peters et al., 1999, *American Journal of Gastroenterology*).

The difference becomes dramatic in longer events. Pfeiffer et al. (2012) documented that **severe GI distress occurred in just 4% of marathon runners and cyclists, but in 32% of Ironman competitors** — who must run a marathon after already stressing their gut for 5+ hours on the bike (Pfeiffer et al., 2012).

A systematic review on gastrointestinal distress noted that *"an estimated 30-90% of endurance athletes engaging in marathons, triathlons, and running report experiencing GI symptoms during exercise"* (ter Steege et al., 2008).

How This Affects Your Recommendations

Based on this research, Mealvana applies sport-specific adjustments:

Sport	Practical Carb Ceiling	Evidence Base
Cycling	80-120 g/hr	Stable platform, no impact, can eat solids (Jeukendrup, 2011)
Running	50-70 g/hr	GI jostling limits absorption (Peters et al., 1999)
Swimming	Pre/post only	Can't fuel during; reduced sweat anyway (Jeukendrup et al., 2005)

The Brick Workout Penalty

If you're doing a brick (bike → run), your run fueling should be even more conservative. Your gut has been working hard on the bike, blood flow patterns are shifting, and the sudden switch to running impact often triggers GI issues.

Research on triathlon-specific nutrition confirms this effect: *"the change in body position among the three disciplines may impair gastric emptying and increase GI distress"* (Jeukendrup, Jentjens & Moseley, 2005, *Sports Medicine*).

A study comparing gel vs. liquid carbohydrate during simulated long-distance triathlon found that **7 of 12 participants reported GI discomfort with gels, while none reported issues with liquid carbs** (Sareban et al., 2016, *International Journal of Sport Nutrition and Exercise Metabolism*).

Mealvana automatically reduces your run carb target by 20-30% when it detects a brick workout pattern in your TrainingPeaks calendar.

Example:

- Standalone 90-min tempo run: 55 g/hr recommendation

- 90-min run off a 3-hour bike: 40-45 g/hr recommendation

Part 4: Sodium — More Personal Than You Think

Your Sweat Is Unique

Here's a number that might surprise you: **athletes can lose anywhere from 200 to 2,000 mg of sodium per liter of sweat**. That's a 10x difference between the saltiest and least salty sweaters.

This massive range has been documented across multiple studies. Baker et al. (2016) analyzed 506 athletes and found sweat sodium concentrations ranging from **230 to 1,840 mg/L, with a mean of 826 mg/L** (Baker et al., 2016, *Sports Medicine*).

Your sweat sodium concentration is largely genetic — you're either a salty sweater or you're not. Heat acclimation helps reduce it somewhat, but the range between individuals remains enormous (Baker et al., 2017).

How Mealvana Calculates Your Sodium Needs

The formula:

```
Sodium Loss (mg/hr) = Sweat Rate (L/hr) × Sweat Sodium Concentration (mg/L)
```

This approach aligns with the ACSM Position Stand on Exercise and Fluid Replacement: *"Because there is considerable variability in sweating rates and sweat electrolyte content between individuals, customized fluid replacement programs are recommended"* (Sawka et al., 2007, *Medicine and Science in Sports and Exercise*).

Example — Two Athletes, Same Workout:

Athlete	Sweat Rate	Sodium Concentration	Hourly Loss
Sarah	1.2 L/hr	900 mg/L	1,080 mg/hr

Athlete	Sweat Rate	Sodium Concentration	Hourly Loss
Marcus	1.8 L/hr	1,400 mg/L	2,520 mg/hr

Marcus loses more than **twice** as much sodium as Sarah in the same workout. Their fueling plans need to reflect this.

This isn't just academic. Baker et al. (2019) demonstrated significant sport-specific differences in sodium losses, with American football and endurance athletes showing the greatest need for deliberate replacement strategies (Baker et al., 2019, *Journal of Sports Sciences*).

Setting Your Profile

In Mealvana, you can input:
- **Sweat rate** (L/hr) — Measure by weighing yourself before and after a 1-hour workout
- **Sodium loss rate** (mg/L) — From a sweat test, or use our estimate based on your description

If you haven't done a formal sweat test, we use research-based defaults from Baker et al. (2016):
- Average sweat sodium: ~900 mg/L
- Range for "salty sweater" profile: 1,200-1,500 mg/L
- Range for "light sweater" profile: 400-600 mg/L

Sodium Replacement Guidelines

How much should you replace? Research suggests targeting 50-80% replacement during exercise is both practical and effective. The International Society of Sports Nutrition recommends **500-700 mg of sodium per liter of fluid** for ultra-endurance events (Tiller et al., 2019, *Journal of the International Society of Sports Nutrition*).

For hot/humid conditions (>25°C and/or >60% humidity), intake should increase to **300-600 mg sodium per hour** (Tiller et al., 2019).

Part 5: Fluid — Matching Your Sweat Rate

The Goal

The research consensus is clear: **don't lose more than 2-3% of your body weight from dehydration during exercise**. Beyond that threshold, performance drops measurably (Sawka et al., 2007).

But here's the flip side: **don't over-drink either**. Hyponatremia (dangerously low blood sodium from drinking too much plain water) is a real risk in long events, particularly marathons and Ironman races (Hew-Butler et al., 2015).

Sweat Rate Variability

Just like sodium concentration, sweat rates vary dramatically. The research documents a range of **0.5 to 2.5+ L/hr** depending on:

- Exercise intensity
- Environmental conditions (heat, humidity)
- Body size
- Fitness level and heat acclimation
- Genetics

(Baker et al., 2016, *Sports Medicine*)

How Mealvana Calculates Fluid Targets

We start with your sweat rate and apply a practical replacement factor:

```
Fluid Target (ml/hr) = Sweat Rate (L/hr) × 1000 × Replacement Factor (0.7-0.9)
```

The replacement factor accounts for:
1. Some fluid produced from metabolism
2. Perfect 100% replacement isn't necessary or practical
3. You'll consume additional fluid with food

Environmental Adjustments:

Research documents significant environmental effects on sweat rate and fluid needs:

Condition	Fluid Adjustment	Evidence
Hot (>25°C / 77°F)	+25-40%	Tiller et al., 2019
Humid (>70%)	+20-30%	Sawka et al., 2007
Cold (<10°C / 50°F)	-30-50%	Reduced but not eliminated sweat
Indoor trainer (no wind)	+30-50%	No convective cooling dramatically increases sweat
Altitude (>2000m)	+15-25%	Increased respiratory water loss

That indoor trainer adjustment is no joke — without wind cooling, sweat rates can nearly double. A German position statement on fluid replacement notes that athletes should pay particular attention to hydration during indoor training (Mosler et al., 2020, *German Journal of Sports Medicine*).

Part 6: Post-Workout Nutrition — Optimizing Recovery

What you eat after your workout determines how well you recover — and how ready you'll be for tomorrow's session. But recovery nutrition isn't one-size-fits-all. The optimal approach depends on what you just did, when you're training next, and your overall goals.

The Three Goals of Recovery Nutrition

Post-workout nutrition serves three primary purposes:

1. **Replenish glycogen stores** — Restore the muscle fuel you just burned (Burke et al., 2004)
2. **Repair and build muscle** — Provide amino acids for muscle protein synthesis (Moore et al., 2009)
3. **Rehydrate** — Replace fluid and electrolytes lost through sweat (Shirreffs et al., 1996)

The relative importance of each goal depends on your workout and your schedule.

The Recovery Window: What the Research Actually Says

You've probably heard of the "anabolic window" — the idea that you must eat within 30-60 minutes post-exercise or miss out on recovery benefits. The truth is more nuanced.

Glycogen Resynthesis

Muscle glycogen resynthesis is indeed fastest in the first 30-60 minutes post-exercise, when the enzyme glycogen synthase is most active and muscles are highly insulin-sensitive (Ivy et al., 1988, *Journal of Applied Physiology*).

However, as a comprehensive review noted: "*The importance of immediate post-exercise carbohydrate intake is dependent on the time until the next training session*" (Beelen et al., 2010, *International Journal of Sport Nutrition and Exercise Metabolism*).

The Practical Takeaway:
- **<8 hours until next session:** Timing matters. Start carbs immediately.
- **>24 hours until next session:** Total daily intake matters more than precise timing.

Muscle Protein Synthesis

The protein timing window is wider than once thought. A meta-analysis by Schoenfeld et al. (2013) found that *"the anabolic effect of exercise is long-lasting (at least 24 h), but likely diminishes with increasing time post-exercise"* (Schoenfeld et al., 2013, *Journal of the International Society of Sports Nutrition*).

That said, consuming protein within 2 hours post-exercise is still recommended for optimal muscle protein synthesis, especially if you trained fasted or it's been >4 hours since your last protein-containing meal (Aragon & Schoenfeld, 2013, *Journal of the International Society of Sports Nutrition*).

Post-Workout Carbohydrate: Refilling the Tank

How Much?

The rate of glycogen resynthesis maxes out at approximately **1.0-1.2 g/kg/hour** for the first 4 hours post-exercise (Burke et al., 2004). Consuming more than this doesn't speed up the process — it just gets stored as fat or oxidized.

Recovery Window	Carb Target	Rationale
0-30 min	1.0-1.2 g/kg	Maximizes glycogen synthase activity (Ivy, 1988)
30-60 min	1.0-1.2 g/kg	Continued rapid resynthesis
2-4 hours	1.0-1.2 g/kg/hr	If rapid recovery needed
24-hour total	5-7 g/kg (moderate) to 7-12 g/kg (high volume)	For full glycogen restoration (Burke et al., 2011)

Example for 70kg athlete after a depleting session: 70-84g carbs in first 30 min, repeated hourly for 4 hours if training again within 8 hours.

Carb Quality Matters

High glycemic index (GI) carbohydrates produce faster glycogen resynthesis in the immediate post-exercise period (Burke et al., 1993). Good choices include:
- White rice, white bread, bagels
- Potatoes (not sweet potatoes initially)
- Sports drinks, fruit juice
- Ripe bananas, dates
- Rice cakes, pretzels

For the 2-24 hour window, a mix of high and moderate GI carbs is fine, and whole food sources become preferable for overall nutrition quality.

Post-Workout Protein: Building and Repairing

How Much?

Research consistently shows that **20-40g of high-quality protein** (or **0.25-0.4 g/kg body weight**) maximally stimulates muscle protein synthesis post-exercise (Moore et al., 2009).

A dose-response study found that 20g of egg protein stimulated muscle protein synthesis maximally in young men after resistance exercise, with 40g providing no additional benefit for whole-body protein synthesis (Witard et al., 2014, *American Journal of Clinical Nutrition*).

However, for older athletes (>40) or after particularly damaging exercise (long runs, eccentric work), higher doses of **40g** may be beneficial (Moore et al., 2015).

Protein Quality: Leucine Is Key

Not all proteins are equal for muscle recovery. The amino acid **leucine** is the primary trigger for muscle protein synthesis. Research suggests a **leucine threshold of 2.5-3g** is needed to maximally stimulate this process (Churchward-Venne et al., 2012).

Protein Source	Amount for ~3g Leucine
Whey protein	20-25g

Protein Source	Amount for ~3g Leucine
Eggs	4-5 whole eggs
Chicken breast	120-140g
Greek yogurt	300-350g
Milk	750ml
Plant blend	30-40g (lower leucine density)

Source: van Vliet et al., 2015, Journal of Nutrition

The Carb + Protein Combination

Early research suggested that adding protein to carbohydrate enhanced glycogen resynthesis (Zawadzki et al., 1992). However, subsequent studies clarified that this benefit disappears when carbohydrate intake is already optimal (≥1.0-1.2 g/kg/hr) (Beelen et al., 2010).

The current consensus:
- If you can consume adequate carbs (1.0-1.2 g/kg/hr), adding protein doesn't accelerate glycogen resynthesis
- However, protein is still valuable for muscle repair — so include it regardless
- If appetite or stomach tolerance limits carb intake, adding protein can help compensate

Mealvana recommends both carbs AND protein post-workout — not because they're synergistic for glycogen, but because you need both for complete recovery.

Sport-Specific Post-Workout Guidelines

Different sports create different recovery demands. A 90-minute easy spin doesn't require the same recovery protocol as a marathon.

Running: Highest Muscle Damage

Running creates significant eccentric muscle damage from the repetitive impact and braking forces. Research shows that marathon running causes measurable muscle damage lasting 7-14 days (Howatson & van Someren, 2008).

Mealvana's Running Recovery Adjustments:

Factor	Adjustment	Rationale
Protein priority	Higher (0.3-0.4 g/kg)	Greater muscle damage to repair
Protein timing	Within 1-2 hours	Support repair processes
Anti-inflammatory foods	Encouraged	Tart cherry, omega-3s may help (Howatson et al., 2010)
Long runs (>90 min)	Aggressive carb replacement	Significant glycogen depletion
Easy runs (<60 min)	Moderate recovery meal	Less depleting

Cycling: Primarily Metabolic Stress

Cycling causes less muscle damage than running (concentric-dominant movement) but can create significant glycogen depletion, especially in long or high-intensity sessions.

Mealvana's Cycling Recovery Adjustments:

Factor	Adjustment	Rationale
Carb priority	Higher emphasis	Primary limiter is glycogen
Protein	Standard (0.25-0.3 g/kg)	Less muscle damage
Long rides (>3 hr)	Aggressive carb: 1.2 g/kg/hr	Major glycogen depletion
Intervals/VO2max	Prioritize carbs	High glycogen cost
Easy spins	Minimal recovery focus	Little depletion

Swimming: Unique Recovery Needs

Swimming involves upper body muscles often undertrained in runners/cyclists, creating a different recovery demand. Additionally, cold water immersion affects post-exercise appetite and metabolism.

Mealvana's Swimming Recovery Adjustments:

Factor	Adjustment	Rationale
Protein	Standard to slightly higher	Upper body muscle repair
Carb	Lower than equivalent land sessions	Less glycogen depletion per hour
Timing	May need reminder	Cold water suppresses appetite
Chlorine exposure	Emphasize antioxidants	Oxidative stress consideration

When Time to Next Workout Changes Everything

This is perhaps the most important factor in recovery nutrition: **when are you training again?**

Scenario 1: >24 Hours Until Next Session

For most recreational athletes training once daily or every other day:
- Timing is flexible — eat within 2 hours, but don't stress
- Focus on total daily carb and protein intake
- A balanced meal is fine; no need for specific recovery products

"When a 24-h recovery period is available, the pattern of intake of CHO-rich meals and snacks is not as important as achieving total CHO intake targets" (Burke et al., 2011)

Scenario 2: 8-24 Hours Until Next Session (Two-a-Days, AM/PM Split)

Timing becomes more important:
- Start carbs within 30 minutes: 1.0-1.2 g/kg
- Include protein: 0.25-0.4 g/kg

- Continue carb-rich meals/snacks every 2-3 hours
- Prioritize sleep for hormonal recovery

Scenario 3: <8 Hours Until Next Session (Same-Day Doubles)

Aggressive recovery protocol needed:
- **Immediate** (0-30 min): 1.2 g/kg carbs + 0.3 g/kg protein
- **Hourly** for 4 hours: 1.0-1.2 g/kg carbs
- High GI carbs preferred for speed
- Fluid: 150% of losses (Shirreffs et al., 1996)
- Consider liquid nutrition if appetite is suppressed

Intensity and Duration: Calibrating Recovery to Effort

Not every workout deserves the same recovery treatment. Mealvana adjusts recommendations based on what you actually did.

By Intensity:

Workout Type	Carb Need	Protein Need	Recovery Priority
Recovery/Easy (Z1-Z2)	Low (0.3-0.5 g/kg)	Standard	Normal meal timing fine
Endurance (Z2-Z3)	Moderate (0.5-0.8 g/kg)	Standard	Within 2 hours
Tempo/Threshold (Z3-Z4)	Moderate-High (0.8-1.0 g/kg)	Standard	Within 1-2 hours
Intervals (Z4-Z5)	High (1.0-1.2 g/kg)	Standard-High	Within 1 hour
Race effort	High (1.0-1.2 g/kg)	High	Immediate

By Duration:

Duration	Glycogen Depletion	Recovery Carb Target
<45 min	Minimal (~10-20%)	Normal meal; no special recovery needed
45-90 min	Moderate (~30-50%)	0.5-0.8 g/kg within 2 hours
90-150 min	Significant (~50-70%)	0.8-1.0 g/kg within 1 hour
>150 min	Near-complete (>70%)	1.0-1.2 g/kg immediately + ongoing

Depletion estimates based on moderate-intensity exercise; higher intensity accelerates depletion (Hawley & Burke, 2010)

Post-Workout Hydration: The 150% Rule

You can't fully rehydrate during exercise — you're always playing catch-up. Post-workout is when you restore fluid balance.

Research by Shirreffs et al. (1996) established that athletes must consume **150% of fluid losses** to achieve euhydration, because some fluid is lost to urine production during the rehydration process (Shirreffs et al., 1996, *Medicine and Science in Sports and Exercise*).

Practical Application:
- Weigh yourself before and after exercise
- Every 1 kg lost = 1 L fluid deficit
- Consume 1.5 L for every 1 kg lost over 2-4 hours

Sodium Aids Retention

Plain water is poorly retained. Adding sodium (500-700 mg/L) significantly improves fluid retention post-exercise (Maughan et al., 1994).

Post-Workout Fluid	Sodium	Retention
Plain water	0 mg/L	~50% retained
Sports drink	400-500 mg/L	~70% retained
Oral rehydration solution	800-1000 mg/L	~80% retained
Milk	~500 mg/L + protein	Excellent retention (Shirreffs et al., 2007)

Source: Evans et al., 2017, European Journal of Applied Physiology

Recovery Nutrition for Weight-Conscious Athletes

Some athletes are simultaneously trying to recover and manage body composition. This requires careful balancing.

Key Principles:
- **Never** skip post-workout protein — muscle preservation is critical during caloric restriction
- Carbs can be moderated if >24 hours to next hard session
- After easy sessions, a normal meal is sufficient — no need for additional recovery calories
- Prioritize recovery nutrition after key sessions; be more conservative after easy days

Research shows that protein timing becomes *more* important during caloric restriction, as the margin for error in muscle protein balance is smaller (Areta et al., 2014).

Summary: Mealvana's Post-Workout Decision Tree

When generating your post-workout recommendations, Mealvana considers:

1. **When is your next workout?** → <8 hours = aggressive; >24 hours = flexible timing
2. **What sport did you do?** → Running = protein priority; Cycling = carb priority
3. **How long was the session?** → Duration drives glycogen depletion estimate
4. **How hard was it?** → Intensity affects both glycogen use and muscle damage
5. **What are your goals?** → Performance vs. weight management affects carb recommendations
6. **What time of day?** → Evening workouts get sleep-optimized recommendations

The result: recovery nutrition matched to what your body actually needs, not a generic “eat protein and carbs” recommendation.

Part 7: Putting It All Together — A Worked Example

Let’s walk through how Mealvana generates a complete fueling plan for a specific workout — **before, during, and after**. We’ll use a race example here, but the same calculation logic applies to your Tuesday brick session, Saturday long ride, or Wednesday track workout — just with different inputs.

The Workout

Olympic Triathlon Race

- Swim: 1.5 km (~25 min)
- Bike: 40 km (~65 min)
- Run: 10 km (~50 min)
- Total: ~2:20
- **Conditions:** Warm day (26°C / 79°F), moderate humidity (55%)

The Athlete Profile

- Weight: 68 kg
- Sweat rate: 1.3 L/hr (increases to ~1.5 L/hr in heat)
- Sweat sodium: 1,100 mg/L
- Max carb tolerance: 80 g/hr
- GI sensitivity: Low
- Caffeine sensitive: No
- Next workout: Easy recovery swim in 36 hours

PRE-WORKOUT CALCULATION

Timing Context: Race starts at 8:00 AM. Athlete wakes at 5:00 AM.

Pre-Workout Carbohydrate:

For a 2:20 race at high intensity, we want maximally topped-off glycogen stores.

Timing	Target	Calculation
3 hours before (5:00 AM)	2-3 g/kg = 136-204g carbs	High end due to race intensity
10-20 min before	0.5 g/kg = 30-35g carbs	Final top-up

Pre-Workout Protein & Fat:

Nutrient	Target	Timing	Notes
Protein	15-20g	3 hours before	Support, not priority
Fat	<15g	3 hours before	Minimize to speed gastric emptying
Fiber	Minimal	All day before	Reduce GI risk

Pre-Workout Hydration:

Given the warm conditions (26°C), we apply the sodium loading protocol:

Timing	Fluid Target	Sodium Target	Calculation
Evening before	500ml with dinner	500-800mg	With salty meal
Wake up (5:00 AM)	400-500ml	400-600mg	6-7 ml/kg
1-2 hr before	200-300ml	200-300mg	3-4 ml/kg
10-20 min before	150-200ml	100-200mg	Final sips
Total pre-race	**1,250-1,500ml**	**1,200-1,900mg**	—

Sodium loading calculation for warm conditions: 15-20 mg/kg × 68 kg = 1,020-1,360mg in the 2-4 hours before. We hit the upper range given race importance.

Pre-Race Meal Example (5:00 AM):
- 2 cups white rice with honey (80g carbs)
- 1 banana (25g carbs)
- 2 eggs (12g protein)
- 500ml sports drink (30g carbs + 500mg sodium)
- Salt on eggs + salty broth sipped
- **Total:** ~135g carbs, ~15g protein, ~500-700mg sodium

Final Top-Up (7:40-7:50 AM):
- 1 gel (25g carbs)
- 200ml electrolyte drink (200mg sodium)
- Small sips only — don't overdo it

DURING-WORKOUT CALCULATION

Swim Leg:
- Duration: 25 min
- Fueling: None (can't eat while swimming)
- Sweat: Reduced in water (~50% of land rate) — approximately 0.3L total
- Sodium loss: ~330mg
- Note: Pre-race fueling carries you through (Jeukendrup et al., 2005)

T1 Transition:
- Quick sip of water if available
- No solid food — keep moving

Bike Leg:
- Duration: 65 min
- Intensity: Race pace (high)
- Sweat rate in heat: 1.5 L/hr × 1.08 hr = ~1.6L
- Sodium loss: 1.6L × 1,100 mg/L = ~1,760mg
- Base carb recommendation: 60-75 g/hr for this duration/intensity (Burke et al., 2011)
- Athlete tolerance: 80 g/hr (not limiting)
- **Bike carb target: 60-70g total (~55-65 g/hr)**
- **Bike sodium target: ~1,500mg** (aim to replace ~85%)
- **Bike fluid target: ~1,200-1,400ml** (aim to replace ~80%)

T2 Transition:
- Quick gel (25g carb) + electrolyte sip (200mg sodium)
- This is your last easy fueling opportunity before GI-sensitive run

Run Leg:
- Duration: 50 min
- Intensity: Race pace
- Sweat rate in heat: 1.5 L/hr × 0.83 hr = ~1.25L
- Sodium loss: ~1,375mg
- Base carb recommendation: 40-50 g/hr for 50-min race effort
- **Brick penalty applied:** Reduce by 20% due to bike-to-run GI stress (Jeukendrup et al., 2005)
- **Run carb target: 30-40g total**
- **Run sodium target: ~700mg** (conservative due to GI sensitivity on run)
- **Run fluid target: ~500-600ml** (from aid stations)

DURING-WORKOUT SUMMARY

Segment	Carbs	Sodium	Fluid	Products
Pre-race (3hr before)	135g	600mg	500ml	Breakfast + sports drink
Pre-race (20min before)	25g	200mg	200ml	Gel + electrolyte sips
Swim	—	—	—	—
T1	—	—	Quick sip	—
Bike	60-70g	1,500mg	1,300ml	2 bottles high-sodium mix + 1 gel
T2	25g	200mg	100ml	Gel + electrolyte sip
Run	30-40g	700mg	550ml	1-2 gels + aid station cups
RACE TOTAL	**275-295g**	**3,200mg**	**2,650ml**	—

POST-WORKOUT CALCULATION

Context Assessment:
- Total duration: 2:20 at race effort
- Glycogen depletion: Near-complete (estimated 80-90%)
- Muscle damage: Moderate-high (running component)
- Fluid deficit: Estimated 1.5-2.0 kg body weight loss
- Next workout: 36 hours away (recovery swim)
- Priority: Full recovery, but no ultra-urgent timeline

Post-Race Carbohydrate:

Since the next session is 36 hours away, we don't need the most aggressive protocol — but this was a depleting race, so we still prioritize recovery.

Timing	Target	Calculation	Rationale
0-30 min	1.0 g/kg = 68g	High GI priority	Maximize glycogen synthase window
1-2 hours	0.8 g/kg = 54g	With real meal	Continue replenishment
Rest of day	5-6 g/kg total = 340-400g	Spread across meals	Full restoration by next day

Post-Race Protein:

Running causes more muscle damage than cycling. After a triathlon with a 10K run, protein is important.

Timing	Target	Source Preference
0-30 min	0.3-0.4 g/kg = 20-27g	Fast-absorbing (whey, milk)
Each subsequent meal	0.25-0.3 g/kg = 17-20g	Whole food sources
Daily total	1.6-2.0 g/kg = 110-136g	Elevated for 24-48 hours

Higher protein recommendation due to running-induced muscle damage (Howatson & van Someren, 2008)

Post-Race Rehydration:

Apply the 150% rule (Shirreffs et al., 1996):

Metric	Value	Calculation
Estimated fluid deficit	1.5-2.0 kg	Body weight loss
Rehydration target	2.25-3.0 L	150% of deficit
Timeline	Over 2-4 hours	Don't chug — sip steadily
Sodium to include	1,500-2,000mg	500-700mg per liter

Post-Race Sodium:

Sodium is critical for fluid retention. Without it, much of what you drink ends up as urine.

Timing	Sodium Target	Source
0-30 min	500-700mg	Recovery drink or salty snack
1-2 hours	500-800mg	With meal (salt food liberally)
Rest of day	Match sweat losses	Normal salty eating

Anti-Inflammatory Considerations:

After the running component, consider foods that may support recovery:
- Tart cherry juice: 8-12 oz (may reduce muscle soreness) (Howatson et al., 2010)
- Omega-3 rich foods: Salmon, walnuts, chia seeds
- Avoid NSAIDs: Ibuprofen impairs gut barrier and may slow recovery (Van Wijck et al., 2012)

POST-RACE RECOVERY PLAN

Immediate (0-30 min):
Nutrient	Target	Example
Carbs	68g (1.0 g/kg)	Recovery shake + banana
Protein	25g (0.35 g/kg)	Whey protein in shake
Fluid	500-750ml	Sports drink or chocolate milk
Sodium	600mg	In recovery drink + salty snack

Practical option: 500ml chocolate milk (50g carbs, 16g protein, 300mg sodium) + banana (25g carbs) + salted pretzels (15g carbs, 400mg sodium) + 250ml water

1-2 Hours Post (Recovery Meal):
Nutrient	Target	Example
Carbs	54g (0.8 g/kg)	Rice, pasta, or potatoes
Protein	25-30g	Chicken, fish, or eggs
Fat	Moderate	Acceptable now
Fluid	750ml-1L	Water with meal + electrolyte drink
Sodium	700-1,000mg	Salt food, salty sides

Practical option: Grilled chicken (30g protein) + large serving white rice (60g carbs) + steamed vegetables + soy sauce (sodium) + 8oz tart cherry juice + 500ml water

Evening/Rest of Day:
- Continue eating carb-rich meals until ~350-400g total for day
- Include protein at each meal (20-30g)
- Continue hydrating until urine is pale yellow
- Consider salty snacks if still feeling depleted
- Prioritize sleep — hormonal recovery happens overnight

COMPLETE NUTRITION TIMELINE

Time	Phase	Carbs	Protein	Sodium	Fluid
Night before	Dinner	100g	25g	800mg	500ml
5:00 AM	Pre-race meal	135g	15g	600mg	500ml
7:45 AM	Final top-up	25g	—	200mg	200ml
8:00-10:20 AM	Race	115-135g	—	2,400mg	1,950ml
10:20-10:50 AM	Immediate recovery	68g	25g	600mg	650ml
12:00 PM	Recovery meal	54g	30g	800mg	750ml
Rest of day	Ongoing recovery	150-200g	60g	1,000mg	1,500ml
24-HOUR TOTAL	—	**650-720g**	**155g**	**6,400mg**	**6,050ml**

This represents a high-carbohydrate race day protocol for optimal performance and recovery. Training days would typically be 30-50% lower in total carbohydrates depending on workout demands.

Part 8: Why Mealvana Is More Than a Lookup Table

You might be thinking: "This is just a table lookup. Duration goes in, carb recommendation comes out." But that's exactly what we *don't* do. Here's how Mealvana's approach differs from the static tables you'll find in textbooks and generic sports nutrition guides.

1. Continuous Functions, Not Arbitrary Cutoffs

Traditional guidelines use step functions with hard cutoffs:

Duration	Traditional Recommendation
45-60 min	30 g/hr
60-90 min	30-60 g/hr
90-150 min	60-90 g/hr

See the problem? A 59-minute workout gets one recommendation. A 61-minute workout jumps to a completely different range. **Your body doesn't work in 60-minute increments.**

Mealvana uses **continuous algorithms** that smoothly scale recommendations across the full duration spectrum. A 59-minute workout and a 61-minute workout get nearly identical recommendations — because physiologically, they're nearly identical workouts.

The same applies to intensity. We don't suddenly flip a switch at "Zone 3 vs. Zone 4." We use your actual workout intensity (from TrainingPeaks TSS and IF data) to calculate recommendations on a smooth curve.

2. We Learn From Your Feedback

Research provides population-level ranges. But you're not a population — you're an individual.

When you log a workout and tell us:
- "Fueling felt perfect"
- "Stomach was a bit off"
- "Bonked at mile 18"
- "Could have eaten more"

...we learn. Over time, Mealvana **narrows your personal band** from the wide population range down to what actually works for *you*.

Example:
- Population range for a 3-hour ride: 60-90 g/hr
- After 10 logged rides with feedback: Your personalized range: 70-80 g/hr

This is the difference between generic advice and a system that knows *you* — your gut, your preferences, your tolerance.

3. Weight-Scaled Recommendations

Here's something most tables ignore: body size matters.

A 55 kg runner and an 85 kg runner doing the same workout have different absolute needs. While carbohydrate oxidation rates are largely gut-limited (not body-size-limited), other factors do scale:

- **Fluid needs** scale with body surface area and sweat rate
- **Sodium losses** scale with sweat volume
- **Absolute glycogen stores** are larger in bigger athletes
- **Practical tolerance** often correlates with body size

Mealvana applies **weight-based scaling** within each recommendation band:
- Lower-weight athletes start toward the lower end of ranges
- Higher-weight athletes start toward the upper end

This isn't just about being bigger — it's about calibrating to your physiology from day one, then refining from there.

4. Multi-Variable Integration

Traditional tables handle one or two variables. Mealvana integrates **all of them simultaneously**:

Variable	How We Use It
Duration	Primary driver of total carb need
Intensity (TSS/IF)	Modifies carb utilization rate

Variable	How We Use It
Sport type	Bike vs. run vs. swim algorithms
Your carb tolerance	Hard ceiling on recommendations
Your sweat rate	Drives fluid/sodium targets
Your sodium concentration	Personalizes electrolyte needs
Environmental conditions	Heat/cold/humidity/altitude adjustments
Workout context	Brick penalties, back-to-back days
Training phase	Taper week carb loading vs. base building

No lookup table can handle this complexity. We calculate your recommendations fresh for every workout, with every variable weighted appropriately.

5. Training Context Awareness

Your Monday long run and your Friday long run might be identical on paper — but if you've done hard sessions Tuesday through Thursday, your Friday needs are different.

Mealvana reads your full TrainingPeaks calendar, not just the individual workout. We know:
- **Back-to-back hard days:** Emphasize recovery nutrition and glycogen replenishment
- **Taper week:** Carb loading protocols for the final days before your race
- **Build phase:** Standard fueling, focus on training the gut
- **Two-a-days:** Adjusted recovery windows between sessions

6. Ranges, Not False Precision

You'll notice Mealvana gives you ranges (60-75 g/hr) rather than single numbers (67.3 g/hr).

This is intentional. The research gives us ranges. Your individual response varies day to day. Weather changes. Stress affects your gut. That gel you usually love might taste terrible at mile 20.

We give you a **target band** — precise enough to be actionable, honest enough to acknowledge uncertainty. Aim for the middle, and you have room to adjust based on how you feel.

7. Workout Intent Matters: Training Mode vs. Race Mode

A Tuesday tempo run and an A-race have different goals — and should have different fueling strategies.

In **training mode**, we optimize for development:
- Room to experiment with products and quantities
- Building gut tolerance gradually
- Learning your personal limits through controlled trial
- Sometimes intentionally under-fueling low-key sessions to enhance fat adaptation

In **race/key workout mode**, we optimize for performance:
- Maximize output within your proven tolerance
- Pre-workout protocols optimized for topped-off glycogen
- Stick with what you've tested — no experiments
- Contingency plans for GI distress

When you mark a workout as a race or key session in TrainingPeaks, Mealvana shifts its recommendations accordingly. Both modes matter — training fueling builds your capacity; race fueling unleashes it.

Part 9: Training Your Gut

Here's something the research has proven: **your gut adapts to what you ask of it**.

A landmark study by Cox et al. (2010) showed that athletes who trained with high carbohydrate intake for 28 days significantly increased their ability to absorb and oxidize carbs during exercise. The high-carb group showed *"higher exogenous carbohydrate oxidation rates during exercise than the low-carb group"* — attributed to improved intestinal absorption (Cox et al., 2010, *Journal of Applied Physiology*).

This adaptation appears to involve upregulation of intestinal transporters (SGLT1 and GLUT5), meaning your gut literally builds more "lanes" for carbohydrate absorption with training (Jeukendrup, 2017).

As Jeukendrup summarized: "*The gut is highly adaptable and endurance athletes should incorporate nutritional training into their training plans*" (Jeukendrup & McLaughlin, 2011, *Nestlé Nutrition Institute Workshop Series*).

What This Means for You

1. **Start conservative** — If you're new to fueling during exercise, begin at 40-50 g/hr
2. **Build gradually** — Add 5-10 g/hr every few weeks
3. **Practice your fueling strategy** — Test products and quantities in training before key events
4. **Use long sessions to test tolerance** — Long rides and runs are perfect for gut training

A systematic review on gut training concluded that *"repeated exposure to high carbohydrate intake during training can impact physiological outcomes; specifically, substrate utilization"* and can help prevent GI distress (Costa et al., 2023, *Sports Medicine*).

Mealvana tracks your training history and will gradually suggest higher carb targets as you demonstrate tolerance over time.

Part 10: When Things Go Wrong — GI Distress

Even with perfect planning, GI issues happen. Research suggests several risk factors, which Mealvana accounts for in its recommendations.

Known Risk Factors for GI Distress

Studies have identified several dietary and non-dietary correlates of GI distress during endurance events:

Risk Factor	Evidence
History of GI issues	Strongest predictor (ρ = 0.32-0.51) (Pfeiffer et al., 2012)
High fiber intake before workout	Increases symptoms (Rehrer et al., 1992)
High fat/protein before workout	Delays gastric emptying (Rehrer et al., 1992)
Concentrated carb solutions (>8%)	Increases GI distress (de Oliveira et al., 2014)
NSAIDs (ibuprofen, etc.)	Compromises gut barrier (Van Wijck et al., 2012)
Dehydration	Exacerbates symptoms (Rehrer et al., 1992)

Source: Wilson, 2015, International Journal of Sport Nutrition and Exercise Metabolism

Red Flags That Trigger Conservative Recommendations

Factor	Mealvana Adjustment
GI sensitivity: High	Reduce carb ceiling by 20-30%
First time at this duration/intensity	Conservative fueling, liquid calories preferred
Hot conditions	Reduce carbs slightly, increase sodium/fluid
Brick run	Reduce run carbs by 20-30%
Caffeine sensitive	Remove caffeine from recommendations

The Backup Plan

For long workouts and races (3+ hours), Mealvana generates a **GI distress contingency** based on field experience from ultra-endurance research:

- If nausea hits: Switch to simple carbs (cola, flat ginger ale) + broth only (Stuempfle & Hoffman, 2015)
- Reduce intensity briefly to allow digestion
- Reduce intake to 30 g/hr until symptoms resolve
- Prioritize hydration over calories

In training, a GI blowup is a learning opportunity. In a race, it's a crisis. Either way, having a plan B ready keeps a bad patch from becoming a DNF.

The Bottom Line

Your Mealvana nutrition plan isn't a guess — it's built on:

✓ **Peer-reviewed research** from leading sports nutrition scientists

✓ **Your personal profile** (weight, sweat rate, sodium loss, carb tolerance)

✓ **Your specific workout** (duration, intensity, sport type)

✓ **Environmental conditions** (heat, humidity, altitude)

✓ **Smart adjustments** (brick penalties, GI sensitivity, caffeine restrictions)

The goal is simple: **give you enough fuel to perform your best, without giving you so much that your stomach rebels.**

Every recommendation comes with the reasoning behind it, so you understand not just *what* to eat, but *why*. Because the more you understand your fueling, the better you can adapt when your workout throws you a curveball.

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Questions about your personalized recommendations? Tap any nutrition target in Mealvana to see the calculation breakdown and the factors that influenced it.

Happy training — and happy fueling!

About Mealvana Endurance

Mealvana Endurance syncs with TrainingPeaks to automatically generate personalized nutrition plans for every workout on your calendar — from easy recovery spins to key brick sessions to your A-race. We translate sports science into practical, actionable fueling strategies so you can focus on training, not spreadsheets.