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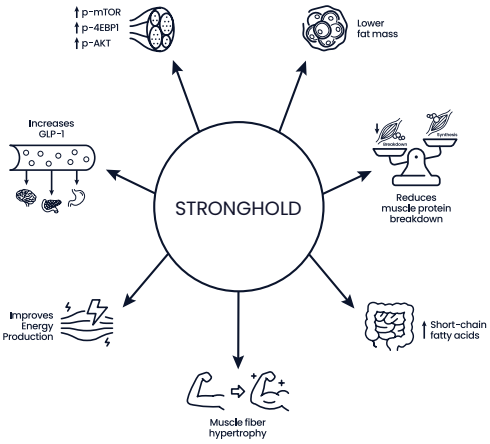
STRONGHOLD: a novel supplement for muscle growth and metabolic health

In this study, the short- and long-term effects of Stronghold on muscle and metabolic health were evaluated by measuring anabolic signaling, GLP-1, fat mass, muscle mass, and other metrics of metabolic function. Stronghold robustly promoted muscle growth, reduced muscle breakdown, enhanced energy production, and elevated GLP-1 levels without any negative impacts on glucose or insulin homeostasis. Stronghold poses a promising and accessible nutritional intervention to counteract anabolic resistance, protect lean mass, and support metabolic health, especially as part of healthy aging or structured weight-loss programs.

Key study outcomes



Background

Aging and catabolic stressors such as caloric restriction and inactivity contribute to anabolic resistance—the diminished capacity of skeletal muscle to respond to anabolic stimuli, contributing to muscle loss and metabolic dysfunction. While resistance training is an effective intervention, it may be inaccessible or insufficient in some populations, highlighting the need for alternative or adjunctive strategies. Nutritional interventions targeting anabolic and anti-catabolic pathways offer a promising approach. In this preclinical study, Stronghold, a novel multi-ingredient supplement designed to combat anabolic resistance, was evaluated for its potential to promote muscle and metabolic health, both after a single serving and with long-term intake.

Methods

Healthy, middle-aged male mice (n = 4 per group) were randomly divided into experimental groups and administered Stronghold or water (Control), with assessments performed after one serving of Stronghold or after long-term daily supplementation (30 days, twice daily). Stronghold is a dietary supplement that contains the active ingredients whey protein isolate, creatine, L-leucine, calcium hydroxymethylbutyrate, vitamin D, and vitamin K[2]. Anabolic signaling, cellular respiration, tissue mass, and fiber cross-sectional area (CSA) were measured in the muscle. Fatty tissue was collected and weighed. Assessments of overall metabolic health included blood glucose, insulin, glucagon-like peptide-1 (GLP-1), C-reactive protein (CRP), and short-chain fatty acids (SCFAs).

Data are presented as the means ± SEM. The differences between Control and Stronghold were compared using Student's t-test. Significance was determined as being at $p < 0.05$, a trend toward significance signaled by $p < 0.1$.

	Healthy, middle-aged male mice	30 days

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Results

Muscle Anabolic Signaling
One hour after ingestion, Stronghold significantly increased cellular signals (p-mTOR, p-AKT, and p-4EBP1) in the muscle, regulating protein synthesis, muscle growth and repair, and glucose metabolism (Figure 1A). With continual Stronghold intake, these cellular signals (p-mTOR and p-AKT) even persisted following a brief fast, indicating that the product elevated the baseline anabolic potential of the muscle (Figure 1B).

Figure 1A

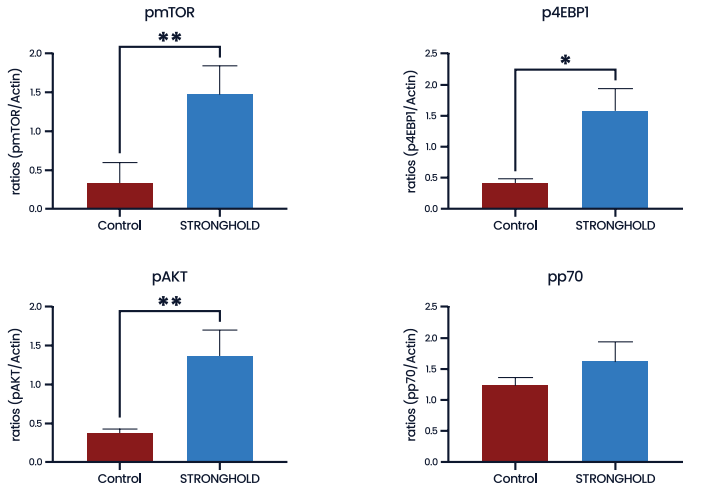

Figure 1B

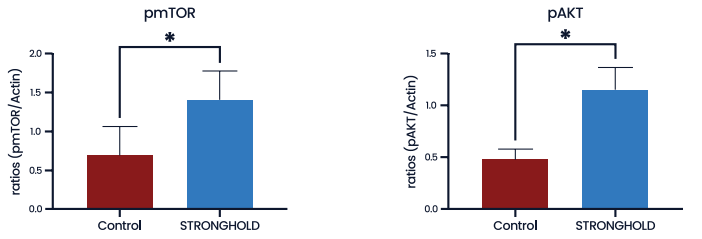

Figure 1. Stronghold increases markers of anabolic signaling, protein synthesis, and glucose metabolism in the muscle after A, one serving, and B, long-term intake. (Control, n = 4; Stronghold, n = 4. *p < 0.05, **p < 0.01)

Results

Incretin and Systemic Metabolic Response

GLP-1, an incretin hormone, plays a role in insulin sensitivity, appetite regulation, weight management, and brain health. Stronghold significantly increased GLP-1 levels both after one serving and after a short fast with long-term intake (Figure 2A and 2B). Additionally, long-term intake increased levels of acetate and propionate, SCFAs linked to a myriad of beneficial metabolic health outcomes (Figure 3). No differences in blood glucose, insulin, or CRP were observed, suggesting that Stronghold does not negatively affect glycemic control or inflammation.

Figure 2A

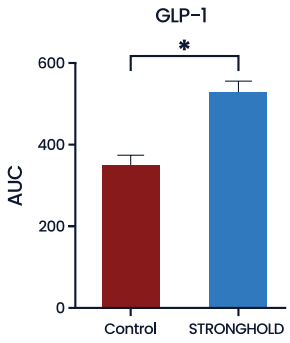

Figure 2B

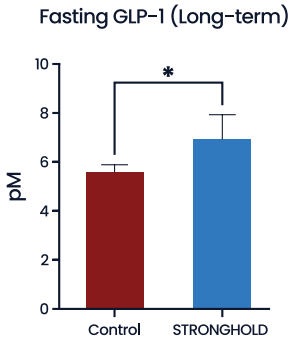

Figure 2. Stronghold increases GLP-1 levels after A, one serving, and B, long-term intake. (Control, n = 4; Stronghold, n = 4. *p < 0.05)

Figure 3

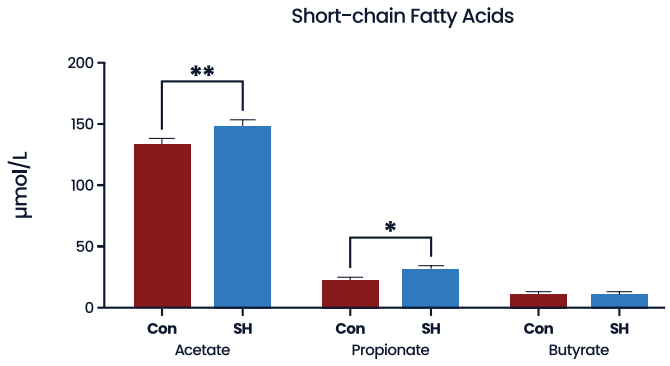

Figure 3. Long-term intake of Stronghold increases levels of the SCFAs acetate and propionate. (Control, n = 4; Stronghold, n = 4. *p < 0.05, **p < 0.01)

Results

Tissue-specific Changes in the Muscle and Fat
Relative to Control, long-term Stronghold intake elicited several positive adaptations, with no observed changes in food intake or physical activity. First, long-term Stronghold intake resulted in greater muscle mass and fiber size, alongside reduced fat accumulation (Figure 4). Consistent with this result, fasted levels of branched chain amino acids (BCAAs) in the plasma were also significantly lower, suggesting that Stronghold exhibits a protective effect on protein turnover, whereas the higher levels of plasma BCAAs in the Control group suggest a state of anabolic resistance (Figure 5). Finally, Stronghold significantly increased cellular respiration, reflecting improved energy production in the muscle (Figure 6).

Figure 4A

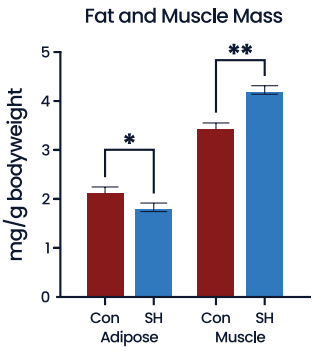

Figure 4B

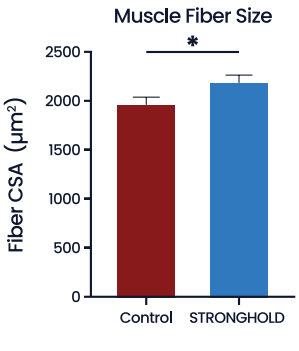

Figure 4. Stronghold consumption increased muscle mass while reducing fat accumulation (A). Muscle fiber CSA was significantly greater with Stronghold versus Control (B). (Control, n = 4; Stronghold, n = 4. *p < 0.05, **p < 0.01)

Figure 5

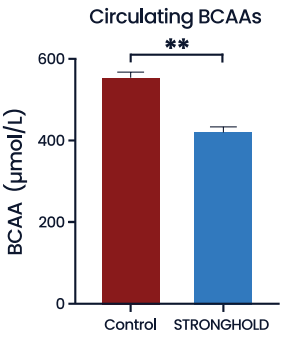

Figure 5. A reduction in fasted plasma BCAAs relative to Control strongly suggests that protein breakdown is significantly lower with long-term Stronghold use. (Control, n = 4; Stronghold, n = 4. **p < 0.01)

Figure 6

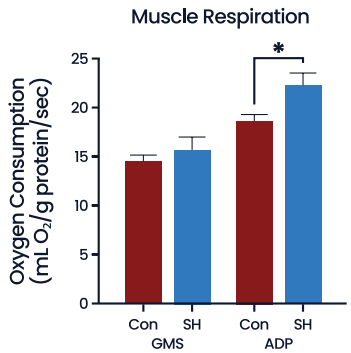

Figure 6. Stronghold consumption increased cellular respiration, suggesting improved energy production in the muscle. (Control, n = 4; Stronghold, n = 4. *p < 0.05)

Conclusion

Stronghold is a promising all-in-one nutritional intervention for improving body composition, muscle maintenance, and overall metabolic health–all relevant factors in anabolic resistance. Relative to control, both short- and long-term intake of Stronghold resulted in significant activation of skeletal muscle anabolic signaling pathways. In addition, long-term intake of Stronghold increased muscle mass and fiber size while concurrently reducing fat mass and protein breakdown, promoting a favorable shift in body composition. Notably, Stronghold enhanced levels of GLP-1 even after a brief fast, suggesting an improved adaptive state. As GLP-1 has known roles in satiety, glucose regulation, and weight management, this finding suggests a broader benefit beyond the muscle. Thus, Stronghold is an accessible means of protecting the body from the effects of anabolic resistance and metabolic dysfunction even amid catabolic stressors.

References

1. Paulussen KJM, McKenna CF, Beals JW, Wilund KR, Salvador AF, Burd NA. Anabolic Resistance of Muscle Protein Turnover Comes in Various Shapes and Sizes. Front Nutr. 2021;8:615849. Published 2021 May 5. doi:10.3389/fnut.2021.615849
2. Hodson N, West DWD, Philp A, Burd NA, Moore DR. Molecular regulation of human skeletal muscle protein synthesis in response to exercise and nutrients: a compass for overcoming age-related anabolic resistance. Am J Physiol Cell Physiol. 2019;317(6):C1061-C1078. doi:10.1152/ajpcell.00209.2019