Branched-Chained Amino Acids: is your recovery missing these essentials?

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ABSTRACT: Two distinct but interrelated pathways, the atrophy pathway FOXO and the catabolic path, the mTOR complexes are affected by BCAAs. The FOXO pathway regulates and promotes breakdown of proteins through ubiquitin binding and proteasome action as well as cell death through apoptosis channels. The mTOR pathway works to promote protein synthesis and other growth pathways like angiogenesis. Experimental dosages of approximately 2-6 g seem to have the greatest effect on the FOXO and mTOR working to mitigate factors like PP2A, TCS1/2, AMPK, which all act to inhibit and downregulate mTOR, while upregulating and activating AKT, RAG complexes, mTOR kinase which activate mTOR while simultaneously downregulating FOXO genes. In both acute and prolonged sessions of endurance training, dosages of BCAAs attenuated and reduced protein breakdown through inactivation of FOXO dependant markers. A similar trend is seen in resistance training regimens and acute bouts, as well as a synergistic effect of exercise on the mTOR pathway in conjunction with BCAAs. Leucine seems to be most prominent in its effect on regulation of both pathways. The digestibility also differs with various sources as does the bioavailability.

Role of BCAAs

- Reduction in central fatigue
- Increase in cognitive performance during prolonged exercise
- Lower Rate of Perceived Exertion (RPE)
- Reduction in Muscular Damage during exercise
- Increase Muscle Protein Synthesis and turnover
- BCAAs induced insulin secretion

Blomstrand J Nutr 2006;136:544S-547S

MECHANISMS

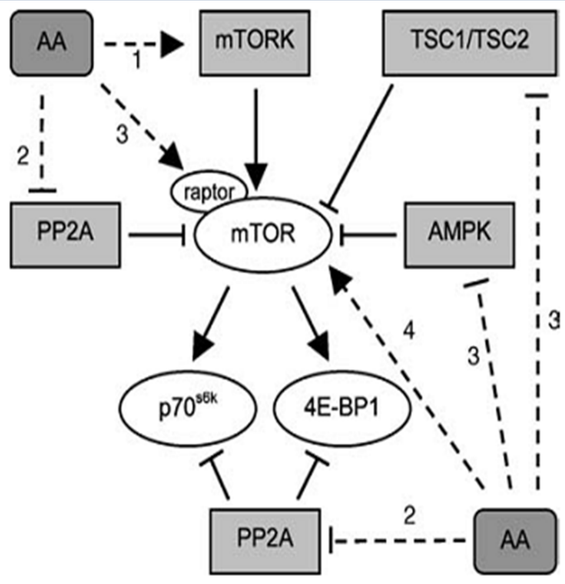
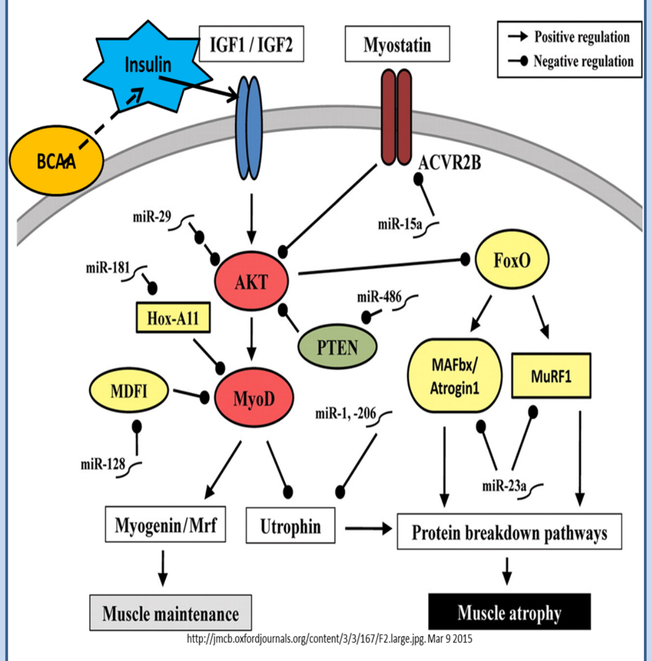


Figure 1: This is a simplified depiction of the BCAA action on regulators of mTOR.
Deldicques et al. Eur Appl Physiol. 2005, 94; 1-10



http://jmcb.oxfordjournals.org/content/3/3/167/F2.large.jpg. Mar 9 2015

Figure 2: The FOXO pathway is shown in a schematic diagram with the actions of BCAA shown.
http://jmcb.oxfordjournals.org/content/3/3/167/F2.large.jpg. Mar 9 2015

Sources of BCAAs

POPULAR FOOD BCAA CONTENT

FOOD	SERVING	PROTEIN	BCAAS	LEUCINE	ISOLEUCINE	VALINE	BCAA (PER G OF PROTEIN)	LEUCINE (PER G OF PROTEIN)
CHICKEN BREAST	6OZ	36G	6.6G	2.9G	1.8G	1.9G	0.18	0.08
95% LEAN BEEF	6OZ	36G	6.2G	2.8G	1.6G	1.8G	0.17	0.08
CANNED TUNA	6OZ	33G	5.6G	2.5G	1.5G	1.6G	0.17	0.08
WILD SALMON	6OZ	34G	5.9G	2.7G	1.5G	1.7G	0.17	0.08
FLANK STEAK	6OZ	36G	6.2G	2.8G	1.6G	1.8G	0.17	0.08
TALAPIA	6OZ	34G	5.9G	2.7G	1.6G	1.6G	0.17	0.08
TURKEY BREAST	6OZ	40G	5.2G	2.8G	1.1G	1.3G	0.13	0.07
EGG	1	6.3G	1.3G	0.54G	0.3G	0.4G	0.21	0.09
EGG WHITE	1	3.6G	0.8G	0.3G	0.2G	0.3G	0.23	0.09
ROASTED PEANUTS	6OZ	12G	6.8G	3.1G	1.7G	2G	0.14	0.07

Figure 3: A chart showing the protein and BCAA content of common foods.
http://www.bodybuilding.com/fun/ask-the-macro-manager-what-are-the-best-food-sources.html. Accessed Mar 22, 2015

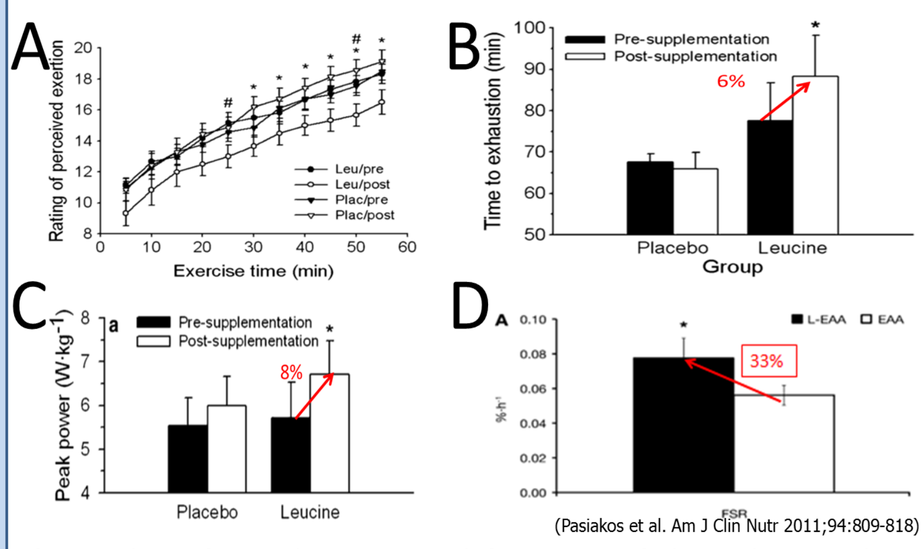
Daily dose of BCAAs specifically leucine found to be around 5 g.

Exercise

Item	Group	Berore ingesting	10 min before exercise[a]	30 min into exercise[b]	Immediately after exercise[c]	30 min after exercise[d]	F Pr > F	post-hoc
CK (U/L)	EG	351.33 122.16						
		MV ± SE	278.47 13.32	292.04 10.26	276.96 16.69	253.84 12.24	3.677 .161	-
	PG	251.00 84.16						
		MV ± SE	285.87 13.32	315.29 10.26	289.87 16.69	273.99 12.24	4.448 .121	-
LDH (U/L)	EG	1175.17 754.89						
		MV ± SE	982.24 125.93	1065.52 132.69	783.04 136.02	734.53 90.79	16.612 .0001	B:C,D
	PG	1002.83 483.60						
		MV ± SE	1058.93 125.93	1315.82 132.69	936.79 136.02	956.47 90.79	16.612 .0001	B:C,D

Table 1: Blood concentrations measured in (U/L) of two muscle damage substances CK (creatine kinase) and LDH (lactate dehydrogenase) for experimental group vs placebo.

Kim et al, J Exerc Nutr Biochem 2013;17:4:169-80



(Pasiakos et al. Am J Clin Nutr 2011;94:809-818)

Figure 4: A) Rate of perceived exertion measured after 60 minutes of exhaustive between pre/post supplementation. B) Time to exhaustion measured in minutes between pre/post supplementation. C) Peak power using an upward arm crank measured in W•kg^{-1} between pre/post supplementation. D) Muscle protein synthesis (MPS) measured by fractional synthetic rate enriched with leucine and essential amino acids.
Crowe et al. Eur J Appl Physiol ,2006;97:510-521

Exercise at 70% of VO_2max until exhaustion

- Blood concentration of all muscle damage substances lower at all measured time intervals
- Perceived exertion was lower at all time intervals for leucine group after 6 weeks supplementation
- Time to exhaustion increased post-supplementation in leucine group
- Peak Power increased post-supplementation in leucine group

Muscle Protein Synthesis

- Greater in L-EAA group by measuring fractional synthetic rate

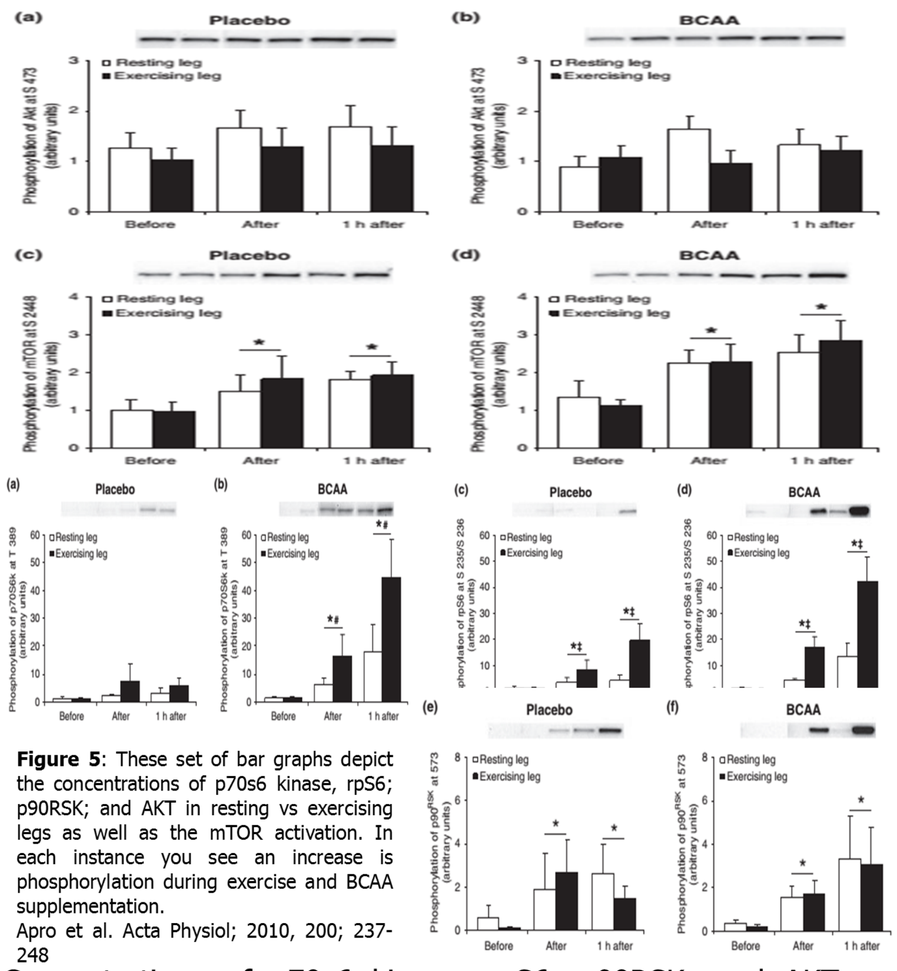


Figure 5: These set of bar graphs depict the concentrations of p70s6 kinase, rpS6; p90RSK; and AKT in resting vs exercising legs as well as the mTOR activation. In each instance you see an increase is phosphorylation during exercise and BCAA supplementation.
Apro et al. Acta Physiol; 2010, 200; 237-248

Concentrations of p70s6 kinase, rpS6; p90RSK; and AKT are indicative of the activation of mTOR and in the placebo groups the exercising leg has more expression of all these factors but when coupled with BCAAs there is a synergistic effect. These graphs also show that mTOR activation is AKT independent. The synergy of both exercise and supplementation creates and exponential growth in concentration that dwarfs the effect of either individually.

Whey vs. Casein vs. Soy

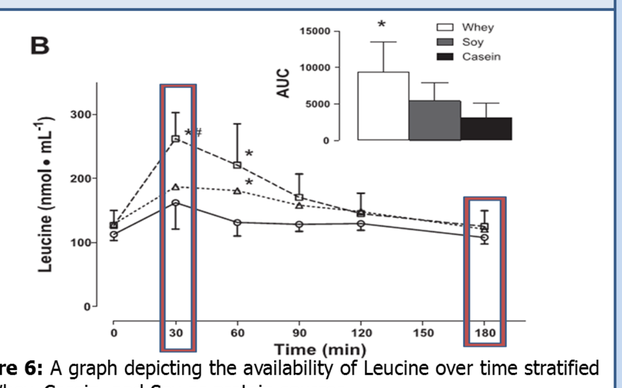


Figure 6: A graph depicting the availability of Leucine over time stratified for Whey, Casein, and Soy as protein sources.
Devries et al. J Food Sci. 2015; 80, 1-15

Conclusion

Branched-chain amino acids are shown to attenuate muscle damage in endurance athletes, but do not have an immediate effect on exercise performance, rather the improvements are seen with chronic use. BCAAs can preserve and improve mental performance in prolonged exercise and reduce the rate of perceived exertion and feelings of fatigue. In resistance training, BCAAs alone increase activation of mTOR and MPS pathways increasing lean muscle mass and strength but when coupled with resistance training have a synergistic effect. Leucine is the most influential component in protein supplementation making whey better than soy for large increases in muscle mass and strength. As in endurance training, BCAA do not change performance during resistance exercise but reduce RPE and attenuate fatigue as well as show a reduction in muscle damage during exercise in Endurance and Resistance training. Based on studies, best source of supplementation would be a high leucine high carb mixed protein supplement pre-workout and whey supplement immediately following exercise followed by a casein supplement 30 minutes after.

Future Research

With the present knowledge of BCAAs, there are certain gaps that still need to be further researched including; age and sex-related effects in the mTOR and FoxO pathway, and whether BCAAs have a greater or lesser effect on trained versus untrained individuals. Another topic that warrants further investigation is the use of BCAA in conjunction with other supplements and macronutrients. Many Studies use a diet but it is known that insulin has some effect on the mTOR pathway activation and that timing will affect the rate of muscle protein breakdown and synthesis due to the deactivation of FOXO and activation of mTOR. Other potential research topics include the study of isoleucine and valine enriched in other essential amino acids to see if there is an effect on muscle protein synthesis and breakdown.

Acknowledgements

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