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The Negligible Effect of BCAA Supplements in Adolescent Nutrition

Grant Mussemann
Saint Louis University

The desire to build or maintain muscle and better oneself drives adolescent nutrition. This often entails the use of supplements, specifically branched-chain amino acids (BCAAs), which vary in effectiveness. As Sarkie Sowers (2009) explains in her "Primer on Branched Chain Amino Acids," the science supporting such products appears sound, offering a quick delivery of nutrients to prevent muscle catabolism, given that BCAAs catalyze protein synthesis. Nevertheless, incentivized, for-profit supplement testing by special-interest groups raises questions of legitimacy. An impartial study conducted by Philip Atherton and his colleagues (2010) found that the effect of BCAA supplements does not differ from that of a high-protein diet due to the time needed to use certain amino acid concentrations. This suggests BCAAs are best applied in regulating the weight of older adults, while providing no benefit for adolescents with high metabolic rates. Mathilde Touvier's correlative findings (2007) indicate that the intrinsic motivation of teens who consume BCAA supplements almost always spurs good nutritional decisions, eliminating the argument that BCAAs could be used to balance an otherwise poor adolescent diet. The timing of branched-chain amino acids appears irrelevant when considered in terms of muscle strength and mass, and the possibility of quickened recovery must be closely examined. Thus, the strictly physical effect of BCAAs is negligible for adolescents, though the supplements could produce a psychological placebo effect.

Introduction

Nutrition is a pillar of physical recovery for athletes, necessary for not only strength gains, but also muscle retention. Overcoming inherent physical limitations of natural strength whilst exceeding the body's ability to maintain a healthy cellular structure necessitates nutritive attention and increased caloric intake. Found gains in endurance likewise result in increased cellular mass and increased nutrition needs. Nevertheless, this endeavor often involves the use of for-profit, unregulated supplements that vary in effectiveness depending on their type, as well as the age of the athlete. Specifically, the effects of branched-chain amino acids, or BCAAs, spark controversy and pose the question of expense without

observable results. Previous studies indicate that the physiological effect of BCAA supplements on adolescents is negligible, though a psychological effect, with supplements acting as placebos, might have physiological results. Further research must be conducted to understand the results of BCAA supplementation in adolescents and expand public knowledge of the supplement industry.

Arguments for BCAA Effectiveness

The scientific reasoning backing branched-chain amino acid supplements appears credible given early-21st century knowledge of human physiology. The modifier "branched-chain" describes carbon atom structures within certain "amino acids," the building blocks for protein and thus for muscle. In her *Primer on Branched Chain Amino Acids*, Huntington College of Heath Sciences Professor Sarkie Sowers summarizes the impact of BCAAs on bodily processes and exercise, while also discussing possible supplemental use. Leucine, isoleucine, and valine are the 3 essential BCAAs normally obtained through digestion of orally consumed proteins. This involves hydrochloric (stomach) acid secretion, pancreatic secretion, small intestine breakdown, and liver oxidation of the proteins (2009, p. 1), an overall lengthy and complex process that might hinder effective muscle formation.

Continuing the discussion of apparent physiological justifications for branched-chain amino acids, Sowers conveys that while orally consumed protein is slowly digested, one's muscles could be destroying themselves from a lack of sufficient outside energy. She explains, "BCAA's comprise approximately 35% of all muscle tissue. They are actively metabolized by muscle as energy . . . 3 to 18% of all workout energy is provided by the BCAA's . . . Because of the great need for Leucine the body must catabolize or breakdown muscle for the Leucine needed during a workout" (Sowers, 2009, p. 2).

35% appears to be a low percent composition for BCAAs when considering their emphasized importance in muscle growth. Therefore, the data suggests that supplementation in addition to orally consumed protein is unjustified. Yet, "actively metabolized" denotes branched-chain amino acids as catalysts for protein synthesis, rather than simply generating new muscle. When an individual performs sufficient exertion for muscle breakdown to begin, protein synthesis commences—the process by which broken-down muscle rebuilds stronger, or new muscle forms. This initiation requires the "3 to 18% of all workout energy" BCAAs provide. Nevertheless, in the absence of adequate nutrition, the muscles will "catabolize" the branched-chain amino acids within them, essentially causing strength to diminish and the muscles to consume themselves. The mention of leucine specifically highlights its observed importance above other branched-chain amino acids and explains its inclusion in other forms of supplementation besides BCAA capsules, such as protein powders. In theory, BCAA supplements expedite and facilitate digestion of orally

consumed protein, allowing quick delivery of nutrients for strength building and prevention of muscle catabolism.

Corporate BCAA Supplement Testing

At first glance, the science backing branched-chain amino acid supplementation appears sound; however, one must also consider the legitimacy of studies funded by for-profit corporations whose special interest is in marketing and selling said products. The National Institutes of Health Office of Dietary Supplements provides simplified information to American consumers about the intended purpose, ingredients, supposed effectiveness, methodological testing, and regulation of dietary supplements, while also offering advice to consumers as a government authority. The various means of questionable testing for corporate-produced supplements is addressed: "They often involve small numbers of people taking the supplement for just a few days, weeks, or months. Most of the research is done in young healthy men, but not women, middle-aged and older adults, or teenagers" (NIH, 2017). "Small numbers" indicates a limited research sample, and "few days, weeks, or months" indicates a limited trial period. Both of these aspects undermine the credibility of BCAA testing, compounded by the inherent bias of the corporation. Having funded the trials, a for-profit company has a vested interest in the results, possibly leading to not only prejudiced interpretations, but skewed data analysis, publication, and peer reviewing.

Limited research demographics also undermine the reliability of supplement testing. "Healthy young men" typically refers to college student volunteers. Having consciously chosen to participate in the trials of an otherwise niche industry, participants likely have intrinsic motivations stemming from individual interests, from athleticism to college credit. Insufficient pre-supplement examination of study participants could skew data accuracy, as could excessive self-reporting during the course of the study. Other demographics, such as "women, middle-aged and older adults, or teenagers" are not considered, though results could vary depending on one's stage in physical development or physical decline. A limited test group suggests limited physical activities tests, each of which might be influenced differently by a participant's consumption of BCAAs. Furthermore, supplements are not tested or approved by the FDA before their sale (NIH, 2017), increasing the probability of ingredient fraud, dishonest labeling, or excessive claims of effectiveness. The niche nature of the supplement industry prevents an objective examination of supplement manufactural practices, necessitating product-specific evaluations by third-party agencies to encourage informed consumer decisions.

BCAA Supplement Ineffectiveness with Sufficient Oral Protein

Despite the limited participant demographics and timespans of current branched-chain amino acid supplement tests, such studies may still

provide specific insights when conducted with impartiality and objectivity. For example, Dr. Philip Atherton—Professor of Physiology at the University of Nottingham—and his colleagues explored whether a protein meal has a similar effect on muscle protein synthesis when compared to amino acid infusion. Healthy, male participants were infused with a leucine tracer and measured using intermittent muscle biopsy. After 2.5 hours, the subjects drank 48g of whey-protein isolate (Atherton et al., 2010, p. 1081). Although the study involved only male participants, results provide a general insight into human physiological responses, which can then be applied tentatively to other demographics. The credibility of the findings is strengthened by a lack of special-interest-group bias toward any specific BCAA supplement and the use of a muscle biopsy as opposed to less-reliable physical activities tests. The research question necessitates both amino acid infusion and oral protein ingestion because amino acids were shown in previous studies to increase muscle protein synthesis. By adding the independent variable of orally consumed protein 2.5 hours after beginning amino acid infusion, a new effect could potentially be observed.

The observed results of Atherton's research support a negligible effect of BCAA supplements with sufficient oral protein intake. Atherton and his colleagues describe the outcome: "Plasma EAA [essential amino acid] concentrations were significantly increased after 30 min, peaked at 60 min (+131%; $P < 0.01$), and remaining elevated for 180 min . . . , whereas nonessential AA concentrations, despite increasing at 30 min (+31%; $P = 0.05$), returned to basal values by 120 min" (Atherton et al., 2010, p. 1083). First addressing "plasma EAA concentrations"—those associated with branched-chain amino acids—"increased after 30 min" reflects increased protein synthesis with amino acid infusion, but "peaked at 60 min" indicates an upper limit of BCAA delivery. At this point, the muscles no longer use BCAAs to catalyze protein synthesis, the excess being diverted toward oxidation (p. 1080). +131% represents the percent increase in plasma EAA concentrations due to amino acid infusion, with the low p-value of $P < 0.01$ indicating the result was statistically significant. "Elevated for 180 min" includes the time oral protein is introduced at 2.5 hours, or 150 minutes. Nevertheless, the plasma EAA concentrations remain at their peak, failing to increase further. This implies that if one ingests sufficient oral protein to reach peak EAA concentrations, then the effect of BCAAs will be negligible. Now addressing "nonessential AA concentrations"—those which physically compose muscle—"increasing at 30 min" again reflects the amino acid infusion; but "returned to basal values by 120 min," before the oral protein is even applied, suggests that protein synthesis, and thus muscle-building, is limited. Physiology dictates that muscle can only be formed at a certain rate. A 31%, increase in nonessential amino acid concentrations when compared to the 131% increase in essential amino acid concentrations appears small, highlighting the importance of BCAAs in catalyzing protein synthesis, and underlining the restrictions of protein synthesis.

Overall, Atherton's study indicates that BCAA supplements are unnecessary with proper oral protein consumption.

Currently understood implications of using branched-chain amino acid supplements with adolescents originate from Atherton's study. Because of the high metabolism found in individuals of this developmental stage, the usefulness of BCAAs is undermined. A nutritious diet can be relied upon to provide the necessary BCAAs for protein synthesis as well as other growth-promoting nutrients. Specifically, complete proteins such as meat, fish, and milk (NIH, 2017) contain branched-chain amino acids. Nevertheless, BCAA supplements have valuable, niche applications in other demographics. For example, the late adult developmental stage is characterized by slower metabolism, making it increasingly difficult to maintain a certain weight. BCAA supplements bridge the gap between receiving all essential nutrients for muscle growth and avoiding abnormal caloric intake. While the use of BCAAs is negligible for adolescents, other groups might benefit due to dietary restrictions.

BCAA Supplements and the Adolescent Diet

Regardless of quick metabolism, one might theorize whether BCAAs are justified for adolescents with poor diets or standards of self-care, offering essential nutrients otherwise lacking. To understand the statistical relationships between supplement use or smoking with an individual's nutrition, Mathilde Touvier (2009)—director of the Nutritional Epidemiology Research Team at the University of Paris—launched a study. A validated, reproducible dietary questionnaire was sent to participants, and 73,034 responses returned that could be analyzed. Using the Scree plot method—which aggregates correlated variables—and logistic regression analysis, Touvier identified 3 main dietary patterns: healthy, Western, and drinker-meat eater. The positive correlation between supplement use and the "healthy" pattern was strong, while the "Western" and "drinker-meat eater" diets inversely correlated to supplement use (p. 42). Likewise, former smoking was positively correlated with the healthy pattern, though current smoking inversely correlated (pp. 42-43).

Essentially, the data of Touvier's study convey that those who use BCAA supplements are likely to already practice healthy lifestyle habits. Being consciously motivated by muscle growth, one would do well to ensure sufficient levels of BCAAs, thus making BCAA supplementation unnecessary. Conversely, less-healthy "Western" diets—characterized by fast food—and "drinker-meat eater" diets correlate with an absence of supplementation. For many individuals lacking a healthy nutritional intake, use of BCAAs is not a conceptualized route, much less a utilized treatment plan. Those who eventually become motivated to eat healthfully are more likely to pursue BCAA supplements. This results in a similar scenario to individuals who may already be eating healthily, rendering the beneficial effects of supplementation negligible. While the use of BCAAs

is potentially justified for adolescents with poor diets, without outside intervention, BCAA supplementation opportunity, utilization, or even awareness is unlikely to arise.

BCAA Supplement Timing

Nevertheless, when an adolescent has a healthy diet, the inquiry arises whether the timing of BCAA supplement consumption could affect potential enhancement properties. Atherton's research (2010) suggests sufficient orally consumed protein undermines the usefulness of BCAAs because of the rate of protein synthesis. However, he fails to consider whether one's BCAA intake within close proximity to the start or end of exercise could impact the rate of protein synthesis itself. A meta-analysis conducted by Lehman College Professor Brad Jon Schoenfeld et al. (2013) compares protein timing's effect on both muscle strength and growth. He interprets the data: "Results refute the commonly held belief that the timing of protein intake in and around a training session is critical to muscular adaptions and indicate that consuming adequate protein in combination with resistance exercise is a key factor for maximizing muscle protein accretion."

Despite measuring protein intake rather than BCAA intake, Schoenfeld's research proves useful because both orally consumed protein and BCAA supplements are shown to impact an individual's amino acid concentrations. The "commonly held belief" that there is a period of time for optimal muscle recovery, also known as the "anabolic window," exists due to a neglect of control over experimental conditions (Schoenfeld et al., 2013), such as the training level, age differences, and diets of participants, as well as other factors previously discussed. Controlling for these variables, the analysis suggests the diminished importance of timing. However, "adequate protein" emphasizes that the quantity of BCAAs consumed, whether by supplement or as orally consumed protein, is a "key factor." Consequentially, the meta-analysis substantiates Atherton's findings.

Though BCAA supplement timing appears negligible regarding strength or mass gains, research suggests other potential benefits with consumption in close proximity to exercise. Fukuoka University Professor Song-Gyu Ra et al. (2018) studied the effect of BCAA supplementation in reducing delayed onset muscle soreness (DOMS) and exercise-induced muscle damage (EIMD) through division of participants into 3 groups: control, PRE, and POST. PRE indicates the BCAA supplement was consumed before exercise, while POST indicates the supplement was consumed afterwards. Results reveal reduced DOMS and EIMD levels in both the PRE and POST groups, the PRE group having a significantly stronger improvement over the POST group. In a separate meta-analysis conducted by University of Alabama Professor Michael Fedewa et al. (2019), findings suggest BCAA supplementation reduces DOMS following exercise (p. 348), corroborating Ra's data. Nevertheless, the

aforementioned research must be closely scrutinized. Ra sampled only 15 participants, each of whom were young men approximately 21 years of age. Although both Ra and Fedewa ensured the inclusion of control groups not given BCAA supplements, they did not account for the diets of participants, which can significantly affect protein synthesis. An alternate consideration is that BCAA supplements reduce DOMS and EIMD levels independent from perceived strength or mass gains. Though said gains correlate to protein synthesis, they do not define the process, opening the possibility of increased protein synthesis after consuming a BCAA supplement in close proximity to exercise. However, one must consider that orally consumed protein could have a similar effect. Further research must be conducted to rule with greater certainty on BCAA supplement timing quickening an adolescent's perceived recovery and its relation to protein synthesis, especially considering the limited demographics of research samples. Until then, current studies do not attribute greater enhancement properties to BCAA supplements than orally consumed protein, suggesting the negligibility of BCAAs with most healthy-eating adolescents.

BCAA Supplements as Placebos

Although the physical effect of branched-chain amino acid supplements is negligible on most healthy-eating adolescents, use of the products could elicit a psychological effect that prompts physiological response, not unlike the well-known placebo effect. Kingston University London Professor Andrea Petróczi conducted a survey involving adolescent, elite UK athletes, identifying the types of supplements commonly used and the different rationales given for using said supplements. She reports her findings: "Young athletes in the present sample appear to be less 'health conscious' and more 'performance focused' than their adult counterparts" (Petróczi et al., 2008). "Less health conscious" suggests an adolescent disregard for optimal physical condition, instead fixating on impressive physical abilities. Thus, adolescents fail to consider the ramifications of the supplements ingested or the actuality of their promised effects. This does not mean, however, that the athletes in question have poor nutrition due to their lack of being "health conscious." Instead, for such individuals, eating healthily stems from their intrinsic motivation to build muscle—observe perceived results—regardless of the actual condition of their bodies. "Performance focused" could suggest unawareness of environmental and unconscious factors. For example, an athlete might credit a BCAA supplement for his stellar competitive performance, when in reality a good night's sleep amounted the difference. Adolescent motivation can sometimes mold perceptions beyond objective reality.

In addition to their observation of adolescent athlete motivations, Petróczi et al. (2008) notes the discordance of justifications given for taking different supplements: "No agreement was observed between athletes' rationale and behaviour in relation to nutritional supplements

except for creatine." Ironically, "creatine" is the most scientifically supported supplement as of 2020 and is generally considered effective. "No agreement" among adolescents regarding the remaining supplements, including BCAAs, suggests both misinformation and the promotion of anecdotal evidence over hard data. Thus, BCAA supplements likely produce a placebo effect in teens—providing a minimal physical advantage, if any, but a psychological boost in confidence. Supplement removal consequentially catalyzes stress; an unwanted physiological response results, not from removal of the BCAA supplement, but the adolescent's belief said removal will negatively impact their performance, as dubbed the "nocebo" effect by University of Duisburg-Essen Professor Ulrike Bingel et al. (2011). Though originally justified as a safety net for missed nutrients, the belief in BCAA effectiveness becomes strongly held without sensible justification. Further research must be conducted to confirm the hypothesized supplement withdrawal effect, and potential BCAA-users must be able to accurately discern between actual symptoms of withdrawal and a phantom psychological confidence "boosting effect."

Possible Side Effects of BCAAs

Regardless of possible psychological influence, the strictly physical side effects of BCAA supplements remain largely unknown. The NIH Office of Dietary Supplements recommends 10-20 grams of BCAAs each day, either through supplement use or orally consumed protein (NIH, 2017). An additional 20 grams appears safe, though individual dietary needs vary. University of Pittsburg Professor of Chemical Biology, John D. Fernstrom (2005), analyzes current research surrounding BCAA side effects and theorizes on excessive branched-chain amino acids' influence on brain function. When BCAA concentrations rise, aromatic amino acid (ArAA) concentrations decline in proportion, which can reduce the synthesis of certain neurotransmitters such as serotonin. This, consequentially, can impact hormones, blood pressure, and emotion (p. 1539S). However, time-course and dose-response relations are largely undetermined, necessitating further study utilizing the known functional effects of BCAAs. With the current data, one appears relatively safe from possible BCAA side effects if he maintains a healthy diet. When considering the use of a BCAA supplement, measured servings and moderate use generally protect against adverse effects.

Conclusions

Despite scientific justifications for branched-chain amino acid supplements, such products are not shown to positively alter the athletic performance of adolescents. Questionable corporate testing involving limited timespans and demographics, combined with a lack of FDA regulation, raises concerns of a BCAA supplement's legitimacy. Atherton's study demonstrates that if a high-metabolizing adolescent consumes sufficient orally consumed protein, then the effect of BCAAs

becomes negligible. The argument for supplementation to counteract poor adolescent nutrition fails to consider psychological motivation, as is lacking in Touvier's research of unhealthy-eating teens. Schoenfeld's research suggests the timing of BCAA supplement consumption is irrelevant for mass and strength gains, and studies examining a quickened recovery through use of BCAA supplementation must be closely scrutinized. Differing adolescent justifications for BCAAs observed Petróczi's survey indicate a possible placebo effect; the belief in BCAA supplement effectiveness overshadows the actual effect of the product. Possible side effects, though unlikely, require close examination of one's genuine need if BCAA supplementation is considered. In an ideal world, performance enhancement could be obtained through intrinsic motivation; the reality is that building strength requires a proper balance, which sometimes includes supplementation.

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