

**Caffeine, Creatine, and Blueberries and their effects on Korean University Student Cognition**

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**Abstract**

Research has been thoroughly conducted to improve memory, processing speed, and attention and focus with the use of caffeine, creatine, and blueberries. The usage of caffeine, creatine, and blueberries in the Korean high carbohydrate diet can improve university and college students' cognitive functioning to perform better in academia. The research conducted suggests that caffeine, creatine, and blueberries will work individually and collectively to improve cognitive functioning in South Korean students, but due to the South Korean's diet and the students' age, students should consume more than the recommended amount of creatine and less than the recommended amount of caffeine.

Keywords: caffeine, creatine, blueberries, cognition, Korea

## **1. Introduction**

The Korean educational system is demanding on students. At the tertiary level, students have been segregated by their Suneung scores and their previous academic performances. The Suneung was created in 1994, and since its inception, it has played an important role student's college admissions Jiyeon Lee discovered when she reported that the Suneung's scores are a key factor in determining which university secondary high school students in South Korea will enter. Lee (2011) reported: "this one test will determine which university they enter. It is considered the chance to make or break one's future." The university that the student attends has a large influence on the future of the student. Kim Da-sol (2016) brought this to light during an interview with Professor Kim Seok-ho from Seoul National University while discussing Koreans desires to rank individuals based on factors other than their ability. "Koreans tend to rank people based on occupation, hometown, academic background and more, which became a prevalent rule of hierarchy here." (Kim, 2016). This desire to rank individuals based on a profile brings pressure to the one thing that students can control, their academic performance. It is imperative that the students are cognitively prepared to do well in their studies at the tertiary level. The foods, liquids, and supplements that university students consume effect their cognitive performance. By consuming creatine, caffeine, and blueberries more frequently and at specific times, students can see improvements in their test scores, study habits, and memory. These small changes can provide both immediate and long lasting positive impacts on the student's performance academically and in their daily life.

## **2. The Korean Diet and Change**

The Korean diet is heavily based on vegetables and white rice. With typical Korean foods, such as kimchi jjigae, doenjang jjigae, juk, rameon, kimchi, bulgogi, bibimbap, and samgyeopsal, providing a nutritional profile that is high in sodium, high in complex carbohydrates, low in fat, and low in calcium (Lee, Popkin, & Kim, 2002). Following a healthy Korean diet does result in some deficiencies; a lack of calcium, iron, vitamin A, and vitamin E. If a student purchases a meal plan university's cafeteria will provide a more complete nutrition profile, while students who do not have access rely on their parents' cooking or eating quick and easy foods such as convenient store rameon, various types of kimbap, coffee, and alcohol which consistent in Lee, Popkin, and Kim's findings that the Korean diet is high in carbohydrates and low in fat.

Students, and most Koreans, rarely use supplements to ameliorate deficiencies in their diet. But adding affordable supplements can help fix these deficiencies as well as improve the minds allowing students to study better, maintain focus, improve their memory, and improve student's results on complex tasks.

**2.1 Change of Diet.** Lee, Popkin, and Kim's 2002 research describing the aspects of nutrition for citizens residing in South Korea shows a protein deficiency that results in lower than optimum cognitive functioning due to the large amounts of carbohydrates South Koreans consume. This is a view substantiated in their research on nutritional transitional trends in Korea. As Lee, Popkin, and Kim (2002) argue the high level of carbohydrate intake is due to the traditional diet. This specific diet is in evidence in both public and private university dining facilities throughout South Korea. These foods are eaten during late night study sessions or during last minute cramming before tests. With a slight change in the diet, the students could learn more effectively during the semester. That would allow them to have less last minute, late night study sessions.

The Korean diet is full of fruits, but it is lacking dark berries according to research conducted by Mok and Hyong (n.d.) in a study that assessed fruit consumption, apples, pears, peaches, grapes, citrus, persimmons, and others, between 1980 and 2003 as well as fruit production from 1974 to 2004. Blueberries, pomegranates, elderberries, blackberries, grapes, etc. are an excellent source of vitamin C, vitamin K, and manganese as well as antioxidants. But these foods are absent from the Korean diet with the exception of grapes. These antioxidants have a number of properties that can help aid in a person's mental abilities. Mok and Hyong's (n.d.) research shows an increase of grape consumption to over 10 kg per capita in Korea in 2000. But that number has been in decline since and in 2003 the grape consumption trend is lowering towards 5 kg per capita in Korea displaying a trend of a lack of antioxidant intake for Koreans in their food consumption.

Blueberries contain two specific antioxidants called pterostilbene and anthocyanins. These chemicals protect the brain and influence its activity by crossing the blood brain barrier in areas regions that are important for learning and memory (Examine.com, 2014; Faloon, 2005). These chemicals are responsible for the increased activity of the neuronal growth factor. When these neurons grow, they branch out towards one another which makes communication between them easier. NGF facilitates the growth of these branches which aids in connectivity within the brain (Examine.com, 2014).

Less than a cup of blueberries, 60 to 120 g, a day can give cognitive benefits. If someone wants to drink blueberry juice instead of eating them, the person would need to drink about 500 ml to obtain the benefits a cup of blueberries provide. If you choose to drink blueberry juice, you need to read the label. The first ingredient listed needs to be blueberries otherwise it will not have the properties needed to receive the benefits (Examine.com, 2014). A third option would be to take blueberry anthocyanin supplements. 500 to 1000 mg of blueberry anthocyanin supplementation would be sufficient to receive the benefits. If the blueberries are not concentrated for anthocyanin, a dosage of 5.5 to 11g is needed.

**2.2 Liquids.** Students use food to meet their nutritional needs as well as for energy to perform their best. Caffeine in coffee, green tea, and energy drinks can provide cognitive benefits while boosting a student's energy. Susan B Roberts (2008) discussed how caffeine can improve the neurotransmitters, dopamine, serotonin, and acetylcholine, in our bodies and releases more catecholamines. These neurotransmitters improve concentration. Dopamine specifically blocks the adenosine receptors in our brain that signal the body that it is time to sleep. Catecholamines like adrenaline cause the body to have an increased heart rate, pump more blood to the muscles, and signal the liver to release more sugar (Roberts, 2008). This gives students the extra energy needed to perform the tasks their college schedule demands.

The caffeine in the coffee consumed by students may help their memory and focus. And with roughly 12,381 coffee shops in 2011, it is available nearly everywhere in Korea. Jin (2012) found that from 2006 to 2011 there was a ten-fold increase in coffee shops. That number is expected to increase every year with the café culture and coffee craze that has consumed Korea since Starbucks' arrival in 1999 (Jin, 2012).

Definitive results linking caffeine and improved cognition are difficult to come by, but there are some positive results. The caffeine in coffee and energy drinks is typically sought out to bring an energy boost, but caffeine has also been found to help keep focus, attention, improve memory, and aid in mentally taxing tasks (Addicott, 2009; Borota, Murray, Keceli, Chang, Watabe, Ly, Toscano & Yassa, 2014; Van Boxtel & Schmitt, 2004). Addicott (2009) contributes by saying, "caffeine provided some performance gains on more cognitively demanding tasks". Van Boxtel & Schmitt (2004) tell us that regular caffeine consumption in young adults, ages 15 to 25, showed positive effects when it came to memory tasks. An additional study performed by John Hopkins University showed that caffeine can help long-term memory, and that caffeine can enhance memories for up to 24 hours after the consumption of caffeine (Borota et al., 2014). Borota et al. (2014) summarized their research when said, "caffeine enhanced consolidation of long-term memories in humans". Borota's et al (2014) research proposed "the mechanisms by which caffeine enhances memory consolidation remain largely unclear" (p. 203).

There is other evidence that shows that caffeine does not provide positive cognitive benefits, but does not hinder or damage cognition (Hogervorst, Riedel, Schmitt, Jolles, 1998; Schmitt, Hogervorst, Vuurman, Riedel, 2003; Smith, 2002). Smith (2002) adds to this by stating, "little evidence suggest[s] impairments following consumption of caffeine" (p. 1246).

With no negative cognitive effects and positive correlations, caffeine should be consumed by students looking to achieve better results in the classroom and on difficult mental activities. Korea's educational focus revolves around memorization and recall. Caffeine can help students focus, aid in their encoding of the information learned, assist in recalling, and help students use this information on complex tasks. A recommended dosage of 200 mg 30 minutes before the student's

study period is enough to achieve the effects that caffeine provides (Examine.com, 2014).

**2.3 Supplements.** In addition to a change in diet and strategically adding caffeine, students can ingest supplements to boost their cognition with products such as *mondafinil*, *Adderall*, and *Nuvigil*. Since the Korean society values the ranking more than the quality of the program, students are looking for ways to become more competitive. Zen Parry (2011) researched how the ranking of a university effected the quality of students the university received as well as where the students worked after graduation. “Korean students compete for placements based on rankings more so than the quality of the programmes. In Korea, it is important to know the university from which someone has graduated. This alumni connection influences employment opportunities” (Parry, 2011). This desire to achieve a higher ranking could lead students to seek out other means to perform better to obtain a higher ranking. While *Mondafinil*, *Adderall*, and *Nuvigil* are drugs available and display improved cognition after using them, *creatine* provides similar results and is more readily available.

*Creatine* is a compound found in fish, chicken, pork, beef, and other protein foods. Lee, Popkin, and Kim (2002) have said that the Korean diet is high in complex carbohydrates and low in fat, but Koreans do not consume enough protein to reap the benefits of *creatine*. Owen and Sunram-Lea (2011) built on Persky and Brazeau’s (2001) research when discussing the benefits of *creatine*. These include: providing the cells with additional ATP, preventing ATP depletion, and allowing the cells to work more efficiently. *Creatine* has been known to provide a cognitive boost in memory and processing speed as well as an increase in grey matter, white matter, cerebellum and the thalamus. But these benefits only appear when enough protein products or *creatine* supplements are consumed. To reap the benefits of *creatine*, a person would need to consume about 500 g of raw meat. Supplementation with *creatine monohydrate* is a preferred, inexpensive alternative way to obtain the needed *creatine*.

*Creatine*’s effects on the brain have been shown to provide better attention and memory. *Creatine* has shown significant positive results on working memory and processing speeds (Brenton & Donohoe, 2011; Deans, 2012; Rae, Digney, McEwan, & Bates, 2003). This means that *creatine* does not seem to help with simple tasks, but it does aid with complicated tasks.

Table 1: Sources of Creatine

Food		Creatine Content g/kg
Fish	Herring	6,5-10
	Salmon	4,5
	Tuna	4
	Cod	3
	Plaice	2
Meat	Pork	5
	Beef	4,5
Other	Breastmilk	0,1
	Vegetables	Trace Amounts
	Fruit	Trace Amounts
	Carbohdrates	Trace Amounts

*Note:* Retrieved from [www.creapure.com](http://www.creapure.com)

Table 1 shows the sources of creatine per 1000 g, but to achieve the effects of creatine, 500 g of meat needs to be consumed to get the benefits of the creatine. Using supplements can be an easier method to get the suggested dosage of 2 – 5 g of creatine, and the ingredient list on the supplement should contain only Creatine Monohydrate (Examine.com, 2014).

### 3. Changes to Cognition Due to Diet

The changes to the brain influenced by the increased protein through creatine, additional antioxidants through dark berries, and the caffeine provide changes to a student's brain that allow the student to gain better focus and attention in addition to improved memory and processing speed.

**3.1 Memory.** There is a tremendous amount of emphasis placed on students' scores and rankings at all levels of education in South Korea. Their education system heavily focuses on memory and recall as opposed to critical thinking and problem solving. It is imperative that students' diet and supplementation aids them in encoding information. Creatine, caffeine, and

blueberries can improve students' memory to meet their educational demands at the tertiary level.

Research and overall discussion of education policies and the corresponding education system in South Korea have to date focused on the emphasis which is consistently placed on student grades as a means to placement and/or ranking and memory recall as a requisite skill to achieve the said end. Such a focus may be found at the expense of abilities that are characteristically desirable in a higher education setting, namely critical thinking and problem-solving skills. Nevertheless, with a view to aiding the existing study habits of higher education students in South Korea, the following dietary recommendations will be addressed. There is overriding evidence that altering diet and consumption patterns to include or increase the intake of creatine, caffeine and blueberries will markedly enhance students' memory performance and thus satisfy existing learning and study requirements in South Korea.

Studies in diet and consumption habits indicate that students in the South Korean higher education system would reap the gains of improved academic performance by supplementing their current daily intake with creatine for the purpose of enhancing memory. The research of Owen and Sandra (2011) in this area has provided the following results on the effects of creatine on healthy students in the 18 to 21 age bracket who were given 5 grams of creatine ethyl per day for two weeks: "the overall findings demonstrated consistent improvements for reaction times across a range of measures as well as improved memory and IQ scores." Beyond the specified enhancement of reaction times, Rae, Digney, McEwan, & Bates (2003) have similarly linked creatine to improvements in memory. Their research proposes that "brain creatine levels correlate positively, with recognition memory" (p. 2149). Benton and Donohoe's (2011) research contributes to previous work when they conducted a double blind study comparing vegetarians and omnivores. Their research showed that the vegetarian's memory benefitted greatly from the creatine consumption. Benton and Donohoe (2011) summarizes this finding when they said, "vegetarians rather than in those who consume meat, creatine supplementation resulted in better memory" (p. 1100). The aforementioned researchers conclude that creatine consumption will demonstrably facilitate advances in memory function. Elementary to higher education level examination formats in South Korea take on the features of multiple choice tests and thus creatine is specifically recommended for encoding and recognition memory.

Creatine's benefits are not limited to memory recall or processing abilities. The supplement has also been found to reduce mental fatigue and enhance mood. Research in this field has established that a reduction in fatigue invariably facilitates improved encoding processes. This finding is specifically relevant to the socio-cultural context of present-day South Korea. As of 2015, South Korea is ranked 2nd according to the World Health Organization among countries with the highest recorded suicide rates. Further research (Lyo, et al., 2012; Strömberg, 2007) has suggested that supplementing diets with creatine will assist in diminishing depressive states which, in turn, will



strengthen memory through marked improvements in mood. Study sessions are likely to improve given the benefits of creatine on efficient information retrieval.–

Creatine is not a well-known cognitive supplement but caffeine is. Caffeine in higher education is commonplace and the benefits of the consumption of caffeine have been well documented. Caffeine has also been shown to help improve consolidation of memories (Borota, et al 2014; Favila & Kuhl, 2014). This finding supports earlier studies conducted by Loke (1988) on caffeine's aid in recall ability: "In general, high-to-moderate users of caffeine recalled more words than low users." (p. 367). This improved encoding has been proven in both fatigued and alert individuals (Smith, Sutherland, & Christopher, 2005; Smith, 2003). Students would benefit from the consumption of caffeine before the beginning of classes regardless of their level of fatigue.

In addition to creatine, blueberries have two antioxidants that can improve memory: pterostilbene and anthocyanins. Adding blueberries to the Korean diet will improve the cognition of the students by helping the neurons in the brain grow and aiding the connectivity of the brain. McCormack and McFadden (2013) continue by saying that, "blueberry-derived polyphenolic compounds in regions important for learning and memory assessed the impact of blueberry supplementation on brain tissue. The findings suggest that blueberry-derived compounds exert neuroprotective effects by crossing the blood brain barrier and altering central nervous system signals." Blueberries can also specifically improve delayed recall (Whyte & Williams, 2015). This stems from the pterostilbene and anthocyanins being correlated with the hippocampus and working memory (Dodd, 2012; Whyte & Williams, 2015). The antioxidant improves the neurological function of the hippocampus improve working memory which aids encoding. This improved encoding aids in the delayed recall of items, something that the Korean education system places a heavy focus on.

**3.2 Processing speed.** Processing speed is an ability that students in South Korea need to perform well on their various exams, such as university exams, TEOFL, IELTS, and subject specific exams, and to comprehend the lessons the student is receiving in the classroom. If there are ways to improve their processing speed, then the student could cover more material in class, examine more examples of the lessons covered, or discuss application of the lessons learned in class.

Research on caffeine is extensive and the effects of caffeine on processing speed is similar in both alert and fatigued participants (Loke, 1988; Smith, Sutherland, Christopher, 2005; Warburton, Williams, & Sweeney, 2015). Smith, Sutherland, and Christopher (2005) specifically researched caffeine's effects on processing new information concluding that it indeed does improve information processing as well as alertness. Their results are synonymous with previous studies conducted by Loke and are congruent with a later study performed by Warburton, Williams, and Sweeney in 2015.

Creatine has also shown to provide improvements for processing speed. Rae, Digney,

McEwan, & Bates (2003) said, "Creatine plays a pivotal role in brain energy homeostasis" (p. 2147). Creatine's crucial roles in the brain's computational power makes it influential in its role for processing speed (Paul et al., 2007; Rae et al., 2003). It helps improve working memory and intelligence, both of which require speed of processing. Korean students would benefit from creatine supplementation because of the additional energy the brain has to use. This gives students an improved mood, better perception, and improved memory because of the additional ATP available in the cerebellum, thalamus, white matter, and grey matter.

**3.3 Attention and Focus.** Attention and focus during class and while studying can be difficult, but with the correct diet, students can get a timed increase in attention and focus to be more efficient mentally as well as more attentive in class to facilitate cognitive processes. Augmenting the diet to include caffeine, creatine, and blueberries helps students be more attentive, aware, and focused in the classroom. These benefits will allow the student better cognitive functioning which specifically assists learning and classroom performance.

Creatine and blueberries provide support to assist the memory and processing speed of the brain, and caffeine can directly assist attention and focus. Korean classes are traditionally teacher focused with the students listening for the entire class session. Caffeine can provide the additional boost in attention, energy, and focus needed to listen attentively to gain the necessary information (Smith, 1999). Smith's (2002) research supports caffeine's effect to increase attention, decrease boredom, and improve encoding: "Caffeine increases alertness and reduces fatigue. This may be especially important in low arousal situations" (p. 1243). In addition to the increased attention and focus, caffeine can decrease boredom (Loke, 1988). This decreased boredom contributes to the attention and focus that students obtain from the caffeine. Additional research done by Griffiths, Juliano, and Chausmer (2003) supported Loke's and Smith's research and expanded their findings noting that caffeine increases a series of factors related to mood. Their research proposes, "In caffeine nonusers or intermittent users, low dietary doses of caffeine (20-200 mg) generally produce positive mood effects such as increased well-being, happiness, energetic arousal, alertness, and sociability." (Griffiths, Juliano, & Chausmer, 2003, p.3)

Caffeine plays a major role in attention and focus, but creatine does as well. Creatine can provide additional ATP to the cells in the brain. The additional energy that is used to improve memory and processing speed also provides additional help in attention. When students take creatine, it helps reduce mental fatigue (Rae et al., 2003) because of the additional energy provided to the cells. When combined with the use of caffeine and blueberries, students will see an improvement in their studying, increased amount of information retained from lectures, and become more effective learners.

#### **4. Criticisms**

While caffeine has positive effects on the brain, there are potential negative side effects that could be present. Griffiths, Juliano, and Chausmer's (2003) extensive study of caffeine found that caffeine can be addictive, disrupt sleep, cause anxiety, cause jitters, and create caffeine dependence. Withdrawal from caffeine can cause headaches, fatigue, sleepiness or drowsiness, difficulty concentrating, work difficulty, irritability, depression, anxiety, flu-like symptoms, and impairment in psychomotor, vigilance, and cognitive performances (Griffiths, Juliano, & Chausmer, 2003). These effects need to be taken into account and students who are frequent users of caffeine should be monitored.

While creatine, caffeine, and blueberries can augment the brain's cognitive functioning to improve learning aspects in the classroom for South Korean university students, it does not ameliorate the body's tolerance of caffeine. According to research conducted by Griffiths, Juliano, and Chausmer (2003), complete caffeine tolerance can occur at high doses, 750 to 1200 mg a day spread throughout the day, counteracting the effects of caffeine and making them equivalent to the placebo groups. At low doses, caffeine could produce an incomplete tolerance where only some of the effects of caffeine.

#### **5. Discussion**

South Korean university students stand to benefit from altering their diet to include more creatine and antioxidants as well as the timing of caffeine consumption to improve their cognitive functioning. Due to the Korean high-carbohydrate and high - vegetable diet, students would benefit from a daily intake of 10 to 15 g of creatine, duplicating the results we saw in Benton and Donohoe's vegetarian research. In addition to daily creatine consumption, blueberries should be added to the diet to provide antioxidants. Consumption of 500 ml of blueberry juice or 100g of raw blueberries is sufficient for South Korean students, but increasing this amount is susceptible to increase the benefits with diminishing returns. As for caffeine consumption, due to the age of the students, 100 g of caffeine is suggested 30 minutes before the start of class or studying. Daily consumption of caffeine is not recommended to avoid building up a tolerance or dependence; students should use caffeine two to four times a week to aid their studies.

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