Brain Chemistry with Tryptophan

With advancing age, chronic inflammation interferes with the production and release of **serotonin**, resulting in mood disorders such as depression, anxiety, irritability, and reduced motivation. **Serotonin** levels increase in response to the amino acid tryptophan. Proper use of **tryptophan** can *reverse* the behavioral symptoms of age, while improving mood, sleep quality, and exercise motivation.

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Aging is often accompanied by a spectrum of mood disorders that include irritability, stress, and anxiety. These symptoms, along with more severe ones like sleep disorders, depression, aggressive behavior, reduced motivation, and suicidal thinking have all been traced to depletion of brain levels of **serotonin**, a neurotransmitter that has been called the "happiness hormone."[1-3]

With the progression of age, chronic, low-grade inflammation sets the stage for degenerative disease in almost every area of the body.[4] While this inflammation often leads to diabetes, cancer, and heart disease, it also affects the brain by interfering with the production and release of **serotonin**.[1-3,5]

In order for your body to manufacture serotonin, it needs a sufficient supply of the natural amino acid, **tryptophan**.[1] Much of what is now known about the role of serotonin in psychiatric and behavioral disturbances comes from studies of **tryptophan depletion**.[6,7] Lowering tryptophan levels triggers a corresponding drop in brain serotonin production and can impact mood, impair memory, and increase aggression.[7]

Although you can't supplement with serotonin itself, **tryptophan** is readily available as a safe, well-proven supplement.[8] Supplementing with tryptophan helps normalize levels of serotonin and other neurotransmitters. As a result, it can reverse many of the behavioral symptoms of age, including irritability, mood disorders, anxiety, and stress.[9]

WHAT YOU NEED TO KNOW

- Grumpiness, irritability, stress, and anxiety are common in aging adults.
- These symptoms, as well as more severe ones like sleep disorders, depression, post-traumatic stress disorder, and suicidal thinking have all been traced to depletion of brain levels of the neuro-transmitter serotonin, which is responsible for maintaining an "up" mood.
- Although you can't supplement with serotonin itself, its precursor, the amino acid tryptophan, is readily available as a safe, well-proven supplement.
- Supplementation with tryptophan reduces irritability in older adults, in women with premenstrual syndrome, and in people with depression and anxiety.

Tryptophan Helps Regulate Behavior

The scientific literature is clear: Tryptophan supplementation simply makes people nicer![10] With the close connection between tryptophan and the neurotransmitter serotonin, it shouldn't be surprising that supplementing with tryptophan can regulate behaviors that involve serotonin signaling in the brain (such as mood, sleep, and anxiety).[2,5]

Studies in animals reveal marked decreases in territoriality and aggressive behavior when their diets are supplemented with tryptophan.[11-13] Humans experience similar results.

For example, in studies of adults who are self-described as "quarrelsome," **1,000 mg** of tryptophan **three times a day** produced significant increases in measures of agreeableness and agreeable behaviors, and decreases in quarrelsomeness.[10,14] Interestingly, men in one study experienced a reduction in dominance, whereas both men and women experienced a decrease in quarrelsome behavior along with an increase in agreeable behavior and their perception of agreeableness in others.[14]

A study of 10-year-old boys with elevated physical aggressiveness revealed the benefits of a single **500 milligram** dose of tryptophan. In the supplemented group, boys were able to adjust their level of response based on the level of provocation, helping them avoid potentially violent encounters.[15] The supplemented boys were able to take more mature perspectives and to be more helpful in the group—all behaviors that could be achieved by many older adults as well.

Other studies have demonstrated that low levels of tryptophan can have a negative effect on behavior. Patients receiving interferon therapy against hepatitis C infection, for example, experience decreases in plasma tryptophan levels. As a result, those undergoing this therapy are notoriously likely to experience emotional irritability and severe depression as side effects.[16,17] As another example, mice lacking the gene necessary to convert tryptophan to serotonin display extreme compulsive and impulsive behaviors, including intense aggressiveness.[18]

People with naturally impulsive or aggressive personalities may receive the most benefit from supplementing with tryptophan, based on studies of deliberate tryptophan depletion in such patients. Those people react very poorly to low tryptophan levels, with an exaggerated impression of the intensity of fleeting angry expressions on others' faces, and an increase in their angry mood state.[19] Similar effects of tryptophan depletion are seen in adults with attention deficit-hyperactivity disorder, which is closely associated with aggression and impulsivity.[20] Supplementation with tryptophan may offer relief to those patients and their long-suffering families.

THE MULTIPLE ROLES OF SEROTONIN IN THE CENTRAL NERVOUS SYSTEM

Healthy, Balanced Levels of Serotonin Are Required For Control Of:[1]

- Mood
- Aggression
- Pain
- Anxiety
- Sleep
- Memory
- Eating behavior
- Addictive behavior
- Temperature control
- Endocrine regulation
- Motor behavior

Tryptophan Improves Sleep Quality

Poor sleep quality or sleep deprivation is a common cause of irritability and moodiness, especially in older people. Studies show that people who sleep poorly are more likely to consume fats or refined sugars, to eat fewer vegetable portions, and to have more irregular meal patterns.[21]

The two main biomolecules that are involved in the production of normal sleep—the neurotransmitter **serotonin** and the hormone **melatonin**—are both naturally made from **tryptophan** in the body.[22] That makes tryptophan a tremendously valuable supplement for those whose sleep is lacking in either quantity or quality.

Studies dating back to the late 1970s have demonstrated that taking between **1 and 15 grams** of tryptophan at bedtime can help you fall asleep.[23] Even doses as little as **250 milligrams** were found to increase the quality of sleep by lengthening the amount of time spent in the deepest stage of sleep.[23]

During the 1980s, many additional studies demonstrated the benefits of taking **1,000 mg** or more of tryptophan at bedtime. Significant improvements were shown in subjective reports of sleepiness such as a decrease in the time to fall asleep, decreased total wakefulness, and an increase in total sleep time.[24-26] These studies showed their most impressive results in people with mild insomnia, or in those with above-average time it takes to fall asleep.[27]

Those who take tryptophan at bedtime are more likely to wake up with increased alertness, to have clearer

thinking, and to perform better on attention-requiring tasks.[25,28] Unlike sleeping pill drugs, tryptophan induces sleepiness but does not impair performance or produce dependence, nor does it make it harder to be roused from sleep when necessary.[27,29]

One study in older adults demonstrated significant improvements in total sleep time, a decrease in the time to fall asleep and sleep fragmentation or periods of broken sleep following a twice-daily serving of tryptophan-enriched cereal providing **60 milligrams of tryptophan per ounce**.[9] (A ten-ounce serving of this cereal would thus provide **600 mg** of tryptophan.)

Tryptophan may also play a positive role in one of the most dangerous sleep-related complications, **obstructive sleep apnea**. This condition causes repeated episodes of near-awakening that viciously disrupt sleep cycles and places sufferers at greatly increased risk of developing cardiovascular disease in later life.[30-32]

In one study, patients with obstructive sleep apnea who took **2.5 grams** of tryptophan at bedtime showed significant improvement from their baseline sleep patterns, with improvements in the amounts of time spent in "rapid eye movement" (REM) sleep, and shortened time to entering rapid eye movement sleep.[33] Decreased rapid eye movement sleep is associated with poor next-day alertness and feelings of fatigue, sometimes resulting in involuntary falling asleep during daytime (narcolepsy).[34]

Tryptophan Helps Manage Depression

As with sleep disturbances, depression can contribute to irritability, impulsive behavior, and poor judgment.[35] For nearly three decades, serotonin has been recognized as the neurotransmitter of central importance in managing depression; virtually all drug therapies in use today aim at raising levels of serotonin at the synapses where nerve cells communicate.

Boosting and balancing brain serotonin through tryptophan supplementation (as opposed to through drug therapy) is an innovative approach to depression that is gaining more and more traction—especially with the discovery that patients with major depression have low levels of tryptophan.[36]

Studies show that tryptophan compares favorably with prescription antidepressants, either when used alone or in combination with a prescription drug.[37,38] Pharmaceutical antidepressants are slow-acting and may cause temporary or prolonged sleep disturbances. However, combining **2 grams/day** of tryptophan with the prescription antidepressant fluoxetine (Prozac® and others) may speed the onset of action while limiting sleep disturbances. (See the ***Caution*** below)[38]

Studies show that lowering plasma tryptophan levels induces many of the symptoms of major depression in patients who have depression or are at familial risk for the disorder.[39-41]

Intriguingly, one of the major manifestations of depression is negative emotional processing, including a tendency to interpret facial expressions in a negative manner (this can reinforce feelings of sadness and hopelessness that are key features of depressive illness).[42,43] Tryptophan depletion intensifies this effect, while tryptophan supplementation reverses it, creating a pleasant positive bias instead, a result shared with prescription antidepressants but without their side effects.[42,44]

In studies of the milder depressive syndrome known as seasonal affective disorder (SAD), or "winter depression," treatment with bright light (to simulate the longer days of summer) is currently the standard of care. Recent studies, however, demonstrate that tryptophan supplementation is as effective as light therapy, and its effect lasts longer than that of light treatment.[45,46]

CAN TRYPTOPHAN SUPPLEMENTS HELP YOUR WORKOUT?

When you're feeling grumpy, there's nothing quite so rewarding and relaxing as a good workout. But for many people, a good workout is as much of a mental challenge as it is a physical one. Many workouts are limited, not by physical fatigue, but by discomfort and pain, as well as a desire to simply give up and go home.[57,58]

Studies of tryptophan and exercise reveal a startling effect: Supplementation improves exercise performance, strength, and endurance. But more importantly,

supplementation can lead to longer workouts because subjects perceive their level of fatigue differently.

One study showed **a 49%** increase in the length of a hard workout, while another showed that distance runners supplementing with tryptophan covered more than half a kilometer more than placebo recipients.[57,58] Tryptophan-supplemented athletes just don't give up as easily or as early.

The result? Longer, more comfortable workouts, with less pain. That's an outcome even a grumpy old man can smile about.

Tryptophan Reduces Anxiety and Stress

Anxiety and stress responses can have a major impact on social functioning. Extreme situations such as post-traumatic stress disorder can be especially debilitating. The natural protective response to stress and anxiety involve the **serotonin** signaling system, as well as hormone pathways in the brain, pituitary, and adrenal glands.[47]

The connection between tryptophan and serotonin explains why tryptophan supplementation has been found to help reduce anxiety and alleviate stress. Tryptophan supplementation reduces biochemical markers of stress, particularly the hormone cortisol that has many deleterious effects in the human body.

As further evidence, acute tryptophan depletion in people with anxiety disorder or with post-traumatic stress disorder leads to a temporary worsening of their symptoms.[48-50]

Tryptophan Relieves Premenstrual Symptoms

No discussion of irritability and "grumpiness" would be complete without mention of premenstrual syndrome and its more disruptive cousin, premenstrual dysphoric disorder. In both syndromes, a reduction in brain serotonin levels is to blame for the dysphoria (state of unease, the opposite of euphoria), mood swings, tension, and irritability that define them.[51] Standard drug treatment consists of selective serotonin reuptake inhibitors, with their attendant side effects.[52,53]

Studies of tryptophan depletion reveal a worsening of premenstrual symptoms, especially aggression, while a small number of studies have now appeared suggesting that tryptophan supplementation is effective at reducing symptoms.[54-56] In one study of premenstrual dysphoria, a dose of **6 grams/day** produced a significant reduction in dysphoria, mood swings, tension, and irritability, when started on the day of ovulation and continued until the third day of menstruation.[55]

CONSEQUENCES OF ABNORMAL SEROTONIN FUNCTION

Abnormalities of Serotonin Function Are Related To:[1,2,6]

- Behavioral disorders in geriatric patients
- Aggressive and self-injurious behavior
- Sleep disorders
- Depression and seasonal affective disorder (SAD)
- Mania
- Obsessive compulsive disorder
- Eating disorders
- Schizophrenia
- Movement disturbances (tardive dyskinesia, akathesia, dystonia)
- Familial tremor
- Restless legs syndrome
- Multiple sclerosis
- Parkinson's disease
- Huntington's disease
- Dementia

- Anxiety
- Gilles de la Tourette's syndrome
- Substance abuse
- Hypersexuality

Summary

One of the greatest heartbreaks of aging is its association with short tempers, easy frustration, and irritability, resulting in the sometimes accurate stereotype of the "grumpy old man" (or woman).

Today, we recognize that the chronic inflammation that's part of the aging process eats away at our bodies' supply of tryptophan, the amino acid needed to produce the "happiness neurotransmitter," serotonin.

Loss of adequate serotonin in the brain is associated with more than just grumpiness, however. Age-related changes in serotonin levels are responsible for troubling sleep disturbances and for the manifestations of many mental health problems such as depression, anxiety, and post-traumatic stress disorder. Even premenstrual syndrome is now recognized as a consequence of transiently low serotonin levels.

Studies reveal the intimate relationships between tryptophan levels in the blood and serotonin levels in the brain. Tryptophan depletion can replicate symptoms of irritability, mood disorders, anxiety, and stress, while tryptophan supplementation is proving capable of ***reversing*** many of these symptoms.

Instead of taking an expensive pharmaceutical drug to boost your synaptic serotonin levels, consider daily tryptophan supplementation to achieve similar results at less cost and greater safety.

If you have any questions on the scientific content of this article, please call a Life Extension® Health Advisor at 1-866-864-3027.

TRYPTOPHAN: A WORD OF CAUTION

Low to moderate doses of tryptophan (less than about **30 milligrams** per pound of body weight, or about **4.5 grams** in an average 165-pound adult) are safe and generally free of side effects. However, at higher doses tremor, nausea, and dizziness may occur.

Special caution is called for in those taking anti-depressant drugs called selective serotonin reuptake inhibitors (SSRIs), because these drugs delay normal degradation of serotonin within nerve synapses. Excessive tryptophan in combination with such drugs can produce the "serotonin syndrome," consisting of delirium, involuntary muscle contractions, high fever, and coma.[8]

In 1989, a dangerous new syndrome, eosinophilia myalgia syndrome, was traced to contaminated tryptophan supplements, leading the US government to ban tryptophan imports.[8] Since that time, tryptophan supplies in the US have been carefully monitored and are safe. Eosinophila myalgia syndrome is entirely unrelated to tryptophan itself, and should not be considered a side effect of supplement use.

References

1. Sandyk R. L-tryptophan in neuropsychiatric disorders: a review. *Int J Neurosci*. 1992 Nov-Dec;67(1-4):127-44.
2. Russo S, Kema IP, Bosker F, Haavik J, Korf J. Tryptophan as an evolutionarily conserved signal to brain serotonin: molecular evidence and psychiatric implications. *World J Biol Psychiatry*. 2009;10(4):258-68.
3. Capuron L, Schroecksnadel S, Feart C, et al. Chronic low-grade inflammation in elderly persons is associated with altered tryptophan and tyrosine metabolism: role in neuropsychiatric symptoms. *Biol Psychiatry*. 2011 Jul 15;70(2):175-82.
4. Jenny NS. Inflammation in aging: cause, effect, or both? *Discov Med*. 2012 Jun;13(73):451-60.
5. Russo S, Kema IP, Fokkema MR, et al. Tryptophan as a link between psychopathology and somatic states.

Psychosom Med. 2003 Jul-Aug;65(4):665-71.
6. Reilly JG, McTavish SF, Young AH. Rapid depletion of plasma tryptophan: a review of studies and experimental methodology. *J Psychopharmacol*. 1997;11(4):381-92.
7. Bell C, Abrams J, Nutt D. Tryptophan depletion and its implications for psychiatry. Br J Psychiatry. 2001 May;178:399-405.
8. Fernstrom JD. Effects and side effects associated with the non-nutritional use of tryptophan by humans. *J Nutr*. 2012 Dec;142(12):2236S-44S.
9. Bravo R, Matito S, Cubero J, et al. Tryptophan-enriched cereal intake improves nocturnal sleep, melatonin, serotonin, and total antioxidant capacity levels and mood in elderly humans. *Age (Dordr)*. 2012 May 24.
10. Moskowitz DS, Pinard G, Zuroff DC, Annable L, Young SN. The effect of tryptophan on social interaction in everyday life: a placebo-controlled study. *Neuropsychopharmacology*. 2001 Aug;25(2):277-89.
11. Winberg S, Overli O, Lepage O. Suppression of aggression in rainbow trout (Oncorhynchus mykiss) by dietary L-tryptophan. *J Exp Biol*. 2001 Nov;204(Pt 22):3867-76.
12. Wolkers CP, Serra M, Hoshiba MA, Urbinati EC. Dietary L-tryptophan alters aggression in juvenile matrinxa Brycon amazonicus. *Fish Physiol Biochem.* 2012 Jun;38(3):819-27.
13. Moskowitz DS, Pinard G, Zuroff DC, Annable L, Young SN. Tryptophan, serotonin and human social behavior. *Adv Exp Med Biol*. 2003;527:215-24.
14. aan het Rot M, Moskowitz DS, Pinard G, Young SN. Social behaviour and mood in everyday life: the effects of tryptophan in quarrelsome individuals. *J Psychiatry Neurosci*. 2006 Jul;31(4):253-62.
15. Nantel-Vivier A, Pihl RO, Young SN, et al. Serotonergic contribution to boys' behavioral regulation. *PLoS One*. 2011;6(6):e20304.
16. Russo S, Kema IP, Haagsma EB, et al. Irritability rather than depression during interferon treatment is linked to increased tryptophan catabolism. *Psychosom Med*. 2005 Sep-Oct;67(5):773-7.
17. Udina M, Castellví P, Moreno-España J, et al. Interferon-induced depression in chronic hepatitis C: a systematic review and meta-analysis. *J Clin Psychiatry*. 2012 Aug;73(8):1128-38.
18. Angoa-Perez M, Kane MJ, Briggs DI, et al. Genetic depletion of brain 5HT reveals a common molecular pathway mediating compulsivity and impulsivity. *J Neurochem*. 2012 Jun;121(6):974-84.
19. Lee RJ, Gill A, Chen B, McCloskey M, Coccaro EF. Modulation of central serotonin affects emotional information processing in impulsive aggressive personality disorder. *J Clin Psychopharmacol*. 2012 Jun;32(3):329-35.
20. Zimmermann M, Grabemann M, Mette C, et al. The effects of acute tryptophan depletion on reactive aggression in adults with attention-deficit/hyperactivity disorder (ADHD) and healthy controls. *PLoS One*. 2012;7(3):e32023.
21. Peuhkuri K, Sihvola N, Korpela R. Diet promotes sleep duration and quality. *Nutr Res*. 2012 May;32(5):309-19.
22. Mishima K. Melatonin as a regulator of human sleep and circadian systems. *Nihon Rinsho*. 2012 Jul;70(7):1139-44.
23. Hartmann E, Spinweber CL. Sleep induced by L-tryptophan. Effect of dosages within the normal dietary intake. *J Nerv Ment Dis*. 1979 Aug;167(8):497-9.
24. Hartmann E. Effects of L-tryptophan on sleepiness and on sleep. *J Psychiatr Res*. 1982;17(2):107-13.
25. Korner E, Bertha G, Flooh E, Reinhart B, Wolf R, Lechner H. Sleep-inducing effect of L-tryptophane. *Eur Neurol*. 1986;25 Suppl 2:75-81.
26. Hartmann E, Lindsley JG, Spinweber C. Chronic insomnia: effects of tryptophan, flurazepam, secobarbital, and placebo. *Psychopharmacology* (Berl). 1983;80(2):138-42.
27. Schneider-Helmert D, Spinweber CL. Evaluation of L-tryptophan for treatment of insomnia: a review. *Psychopharmacology (Berl)*. 1986;89(1):1-7.
28. Markus CR, Jonkman LM, Lammers JH, Deutz NE, Messer MH, Rigtering N. Evening intake of alpha-lactalbumin increases plasma tryptophan availability and improves morning alertness and brain measures of attention. *Am J Clin Nutr.* 2005 May;81(5):1026-33.
29. Lieberman HR, Corkin S, Spring BJ, Wurtman RJ, Growdon JH. The effects of dietary neurotransmitter precursors on human behavior. *Am J Clin Nutr.* 1985 Aug;42(2):366-70.

30. Seif F, Patel SR, Walia H, et al. Association between obstructive sleep apnoea severity and endothelial dysfunction in an increased background of cardiovascular burden. *J Sleep Res*. 2013 Jan 19. doi: 10.1111/jsr.12026. [Epub ahead of print]
31. Garcia-Rio F, Alonso-Fernandez A, Armada E, et al. CPAP effect on recurrent episodes in patients with sleep apnea and myocardial infarction. *Int J Cardiol*. 2013 Jan 7.
32. Vitulano N, Di Marco Berardino A, Re A, et al. Obstructive sleep apnea and heart disease: the biomarkers point of view. *Front Biosci (Schol Ed)*. 2013;5:588-99.
33. Schmidt HS. L-tryptophan in the treatment of impaired respiration in sleep. *Bull Eur Physiopathol Respir*. 1983 Nov-Dec;19(6):625-9.
34. Han F. Respiratory regulation in narcolepsy. *Sleep Breath*. 2012 Mar;16(1):241-5.
35. Shabbir F, Patel A, Mattison C, et al. Effect of diet on serotonergic neurotransmission in depression. *Neurochem Int*. 2013 Jan 7.
36. Sa M, Ying L, Tang AG, Xiao LD, Ren YP. Simultaneous determination of tyrosine, tryptophan and 5-hydroxytryptamine in serum of MDD patients by high performance liquid chromatography with fluorescence detection. *Clin Chim Acta*. 2012 Jun 14;413(11-12):973-7.
37. Thomson J, Rankin H, Ashcroft GW, Yates CM, McQueen JK, Cummings SW. The treatment of depression in general practice: a comparison of L-tryptophan, amitriptyline, and a combination of L-tryptophan and amitriptyline with placebo. *Psychol Med*. 1982 Nov;12(4):741-51.
38. Levitan RD, Shen JH, Jindal R, Driver HS, Kennedy SH, Shapiro CM. Preliminary randomized double-blind placebo-controlled trial of tryptophan combined with fluoxetine to treat major depressive disorder: antidepressant and hypnotic effects. *J Psychiatry Neurosci*. 2000 Sep;25(4):337-46.
39. Barr LC, Goodman WK, McDougle CJ, et al. Tryptophan depletion in patients with obsessive-compulsive disorder who respond to serotonin reuptake inhibitors. *Arch Gen Psychiatry*. 1994 Apr;51(4):309-17.
40. Paykel ES. Partial remission, residual symptoms, and relapse in depression. *Dialogues Clin Neurosci*. 2008;10(4):431-7.
41. Booij L, Van der Does AJ, Haffmans PM, Riedel WJ, Fekkes D, Blom MJ. The effects of high-dose and low-dose tryptophan depletion on mood and cognitive functions of remitted depressed patients. *J Psychopharmacol*. 2005 May;19(3):267-75.
42. Feder A, Skipper J, Blair JR, et al. Tryptophan depletion and emotional processing in healthy volunteers at high risk for depression. *Biol Psychiatry*. 2011 Apr 15;69(8):804-7.
43. Jaworska N, Thompson A, Shah D, Fisher D, Ilivitsky V, Knott V. Acute tryptophan depletion effects on the vertex and late positive potentials to emotional faces in individuals with a family history of depression. *Neuropsychobiology*. 2012;65(1):28-40.
44. Murphy SE, Longhitano C, Ayres RE, Cowen PJ, Harmer CJ. Tryptophan supplementation induces a positive bias in the processing of emotional material in healthy female volunteers. *Psychopharmacology (Berl)*. 2006 Jul;187(1):121-30.
45. Ghadirian AM, Murphy BE, Gendron MJ. Efficacy of light versus tryptophan therapy in seasonal affective disorder. *J Affect Disord*. 1998 Jul;50(1):23-7.
46. McGrath RE, Buckwald B, Resnick EV. The effect of L-tryptophan on seasonal affective disorder. *J Clin Psychiatry*. 1990 Apr;51(4):162-3.
47. Eshkevari L, Permaul E, Mulroney SE. Acupuncture blocks cold stress-induced increase in hypothalamus-pituitary-adrenal axis in rat. *J Endocrinol*. 2013 Feb 5. s[Epub ahead of print]
48. Corchs F, Nutt DJ, Hood S, Bernik M. Serotonin and sensitivity to trauma-related exposure in selective serotonin reuptake inhibitors-recovered posttraumatic stress disorder. *Biol Psychiatry*. 2009 Jul 1;66(1):17-24.
49. van Veen JF, van Vliet IM, de Rijk RH, et al. Tryptophan depletion affects the autonomic stress response in generalized social anxiety disorder. *Psychoneuroendocrinology*. 2009 Nov;34(10):1590-4.
50. Robinson OJ, Overstreet C, Allen PS, Pine DS, Grillon C. Acute tryptophan depletion increases translational indices of anxiety but not fear: serotonergic modulation of the bed nucleus of the stria terminalis? *Neuropsychopharmacology*. 2012 Jul;37(8):1963-71.
51. Eriksson O, Wall A, Marteinsdottir I, et al. Mood changes correlate to changes in brain serotonin precursor

trapping in women with premenstrual dysphoria. *Psychiatry Res.* 2006 Mar 31;146(2):107-16.
52. Pearlstein T, Steiner M. Non-antidepressant treatment of premenstrual syndrome. *J Clin Psychiatry.* 2000;61(Suppl)12:22-7.
53. Rapkin A. A review of treatment of premenstrual syndrome and premenstrual dysphoric disorder. *Psychoneuroendocrinology.* 2003 Aug;28 Suppl 3:39-53.
54. Menkes DB, Coates DC, Fawcett JP. Acute tryptophan depletion aggravates premenstrual syndrome. *J Affect Disord.* 1994 Sep;32(1):37-44.
55. Steinberg S, Annable L, Young SN, Liyanage N. A placebo-controlled clinical trial of L-tryptophan in premenstrual dysphoria. *Biol Psychiatry.* 1999 Feb 1;45(3):313-20.
56. Bond AJ, Wingrove J, Critchlow DG. Tryptophan depletion increases aggression in women during the premenstrual phase. *Psychopharmacology (Berl).* 2001 Aug;156(4):477-80.
57. Segura R, Ventura JL. Effect of L-tryptophan supplementation on exercise performance. *Int J Sports Med.* 1988 Oct;9(5):301-5.
58. Javierre C, Segura R, Ventura JL, Suarez A, Roses JM. L-tryptophan supplementation can decrease fatigue perception during an aerobic exercise with supramaximal intercalated anaerobic bouts in young healthy men. *Int J Neurosci.* 2010 May;120(5):319-27.

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