AIS SPORTS SUPPLEMENT FRAMEWORK
ABCD CLASSIFICATION SYSTEM

TYROSINE

SUMMARY REPORT: CONSIDERATION FOR CLASSIFICATION OF A SUPPLEMENT INGREDIENT

The ABCD Classification system ranks sports foods and supplement ingredients into four groups according to scientific evidence and other practical considerations that determine whether a product is safe, permitted, and effective in improving sports performance. The classification of supplements and sports foods is made via the consideration of the AIS Sports Supplement Framework Committee and evolves according to new knowledge plus the informed direction of our key stakeholders. This report summarises decisions made regarding the addition or reclassification of a substance within the System, based on evidence provided by the applicant and assessed (and potentially augmented) by the Framework Committee.

SUMMARY REPORT FOLLOWING CONSIDERATION OF ADDITION/ALTERATION OF SUPPLEMENT INGREDIENT	
Name/ Formulation & description	Tyrosine (TYR) is a dietary non-essential amino acid precursor for catecholamine neurotransmitter synthesis. Tyrosine is contained within protein-rich dietary sources and is synthesised in the liver from phenylalanine. It is available: > Commercially in capsules, tablets and water-soluble granules/powder. > Pharmacological grade (I.e., registered medical nutrition provider) water soluble powder.
Current AIS Supplement Framework Classification	Group B
Agreed AIS Supplement Framework Classification	Group C
Proposed benefit(s)	i. Purported ergogenic effects relative to exercise performance (favouring prolonged endurance), particularly/predominantly in the heat (less so cold and/or hypoxia). ii. Purported protection of parameters related to cognitive performance decline relative to exercise performance (favouring prolonged endurance) or stressful exposures, particularly/predominantly in the heat, cold and/or hypoxia. iii. Purported protection of parameters related to cognitive performance decline relative to cold exposure.
Proposed mechanism of action(s)	During prolonged endurance exercise within the heat catecholamine turnover is increased compared to the same exercise in a temperate environment (i.e. the former accelerates fatigue compared to the latter, in part due to central catecholamine depletion of their major precursor TYR).[2, 3] During acute stress, there is an observed increase in the activation of noradrenergic neurons in the frontal cortex, which release neurotransmitter as a response to stress.[4] The continued release of neurotransmitter is fundamental in the ability to cope with stress, and thus as concentrations begin to deplete, aspects of cognitive function start to deteriorate.[5] Therefore, oral supplementation of TYR is proposed to increase its ratio to other large neutral amino acids (LNAA) for competitive transport across the blood brain barrier, thus resulting in a greater cerebral uptake and an increase in dopamine (DA) synthesis in the brain[6, 7]; i.e. facilitative of prolonging/maintaining 'optimal'/'minimal' catecholamine/neurotransmitter presence/function. It is suggested that similar to the effects of physical/exercise/mental stress and/or heat-stress, catecholamine concentrations also become depleted during exposure to other environmental stressors (e.g. cold and/or hypoxia).[8]

Summary of supporting evidence	**Physical Performance** Several studies have investigated the effects of TYR in relation to exercise performance in normal[9-11] and elevated/ high ambient temperatures.[12-15] All three of the studies conducted under temperate conditions failed to observe any beneficial effect of acute TYR ingestion on endurance performance[9, 10] or strength and power performance.[11] These findings are not surprising due to the questionable amount of stress experienced during exercise in normal ambient temperatures and the relationship between stress and catecholamine turnover. Recent studies have therefore focused on passive and active heat-stress based designs to examine the influence of TYR under extreme stress. Data has shown significant improvement in exercise capacity (15 ± 11%) after ingestion of 150 mg/ kg body mass of TYR, compared to placebo when cycling to exhaustion in a hot environment (30°C; 50% RH).[12] To date, this[12] is the first and only study to observe a positive effect of TYR on physical performance, despite the efforts of others[13] who attempted to replicate this study. Indeed, others[13] reported TYR did not influence exercise capacity or any aspects of cognitive function (reaction time, information processing or memory) in the heat, despite a significant increase in plasma TYR concentration. Indeed, others[14] employed a pre-loaded time-trial design based on the theory that a benefit of TYR would be more apparent during self-paced exercise due to the greater influence of behavioural thermoregulation, motivation and arousal compared to constant load exercise.[2, 14] However, this was not the case, as TYR ingestion (150 mg/ kg body mass) did not influence time-trial performance when performed in a hot environment (30°C; 50% RH).[14] Others[15] examined the TYR ingestion (300 mg/ kg body mass) during exposure to a 90 min soccer-simulation protocol (iSPT[16]) in a warm environment (25°C; 40% RH); TYR had a positive effect on cognitive function (vigilance) and readiness to invest mental effort, but did not influence physical performance. **Cognitive Performance (heat/cold/hypoxia):** The majority of literature assessing the effects of TYR is military based, with several investigations conducted by the US Army Research Institute[8, 17-20] and other army institutes.[4, 21] These have primarily focused on aspects of cognitive function (complex; working memory, vigilance, tracking and simple reaction time; etc.) and mood during exposure to acute stress, such as such as cold[8, 17, 20] and hypoxia[17], and paradigms involving both extended wakefulness[22] and the physical/emotional stress nexus.[21] Each of these aforementioned studies has demonstrated improvements in specific aspects of cognitive function after ingestion of TYR (100-300 mg/ kg body mass; N.B. when 300 mg/ kg body mass of TYR is administered, it is typically via two equal dosages 4 hours apart). TYR supplementation has direct mechanistic evidence that it can offset heat-induced delays in reaction time during 90 min passive exposure to 45°C; 30% RH.[5] This study also assessed higher levels of cognitive function using advanced brain imaging techniques (event related potentials; ERP), providing evidence that heat exposure causes an increase in P300 (reduced concentration) and M100 latency (reduced ability to react to a warning) and a decrease in M100 amplitude (linked with attention) which returned to near normal levels after ingestion of TYR. It was concluded that the higher DA and norepinephrine (NE) concentrations detected in the TYR trial might have maintained cognitive function by alleviating the decrements associated with heat-stress.[5] This[5] is the only TYR-heat-stress based study to assess DA and NE concentrations in combination with cognitive testing and advanced brain imaging, currently the 'best' quality evidence regarding the efficacy of TYR during heat-stress to mediate undesirable heat-mediated cognitive function declines.
Limitations to current science	There are a number of limitations to the current science. These include: iv. A diverse range of administration strategies (dose, form and source of the supplement) reported within the literature.[14, 15] v. Lack of investigations in the use of TYR in elite athlete populations. In addition, performance tests rarely reflect elite sport competitive events. vi. Limited data[3, 23] exploring TYR pharmacokinetics in response to pharmacological grade supplementation, limited to dosages of 100 - 300 mg/kg body mass (300 mg/kg body mass dose administered via two equal dosages 4 hours apart). vii. Many exercise or 'stressor' protocols within the current data may not be 'stressful' enough to deplete central catecholamines sufficiently, to surface TYR effects. viii. Mechanistic approaches and thus data to quantitatively assess related blood/brain biochemistry changes (including TYR supplementation upon these) alongside advanced brain imaging techniques. ix. Not all studies report plasma/serum measures of TYR.
Final consensus	The consensus in available evidence suggests TYR does not have efficacy in improving physical performance (endurance or otherwise; irrelevant of environmental stressor(s)). Conversely to physical performance, TYR does have substantial evidence demonstrating its efficacy to improve aspects of cognitive performance during exposure to heat and/or exercise heat stress, however there have been limited investigations in elite athlete populations.

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The Australian Institute of Sport (AIS) Supplement Framework is an initiative of the Australian High Performance Sport System. The AIS acknowledges the support of members of the National Institute Network (NIN) and National Sporting Organisations (NSO) and their staff in delivering content expertise. This information is intended to help athletes, coaches and scientists make evidence-based decisions about the use of supplements and sports foods. Before engaging in supplement use, we recommend that each individual refer to the specific supplement policies of their sporting organisation, sports institute or parent body, and seek appropriate professional advice from an accredited sports dietitian (**www.sportsdietitians.com.au**).

Athletes should be aware that the use of supplements may have doping implications. Athletes are reminded that they are responsible for all substances that enter their body under the 'strict liability' rules of the World Anti-Doping Code. Some supplements are riskier than others. The Sport Integrity Australia (SIA) app is a useful resource to help mitigate the risk of inadvertent doping by helping to identify supplements that have been batch-tested. The SIA App provides a list of more than 11,000 batch-tested products. We recommend that all athletes consult the educational resources of SIA regarding the risks associated with supplements and sports foods.. While batch-tested products have the lowest risk of a product containing prohibited substances, they cannot offer you a guarantee that they are not contaminated (**www.sportintegrity.gov.au/what-we-do/supplements-sport**).

Last updated March 2021

ASC36182