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The Relation Between Melatonin and Exercise

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Melatonin is a hormone that regulates several physiological processes, including circadian rhythms, sleep, and immune function. Recent studies have suggested that melatonin may also play a role in exercise performance and recovery. Exercise-induced oxidative stress and inflammation can cause tissue damage and impair recovery. In addition to its intrinsic antioxidant properties, melatonin stimulates several antioxidative enzymes and enhances the efficacy of others. Melatonin also binds to a number of important antioxidant molecules, and indirectly contributes to the maintenance of the redox status in cells. The study suggests that melatonin may have a protective effect against the oxidative stress induced by exercise. Melatonin administration has increased muscle and liver glycogen content in both sedentary and exercised rats. The exercised groups are higher muscle and liver glycogen content compared to the sedentary groups. Melatonin treatment had no significant effect on body weight or food intake. The authors conclude that melatonin may play a role in regulating glycogen storage in skeletal muscle and liver, which could have implications for exercise performance and energy metabolism. Lactic acid is a byproduct of anaerobic metabolism that can accumulate in the muscle during exercise and contribute to muscle fatigue. The relationship between melatonin and lactic acid during exercise is not well understood, but some evidence suggests that melatonin may help to reduce lactic acid levels in the muscle. Zinc is necessary for melatonin synthesis. Melatonin, in turn, increases the absorption of zinc in the digestive system. The decrease observed in zinc levels after pinealectomy can cause muscle exhaustion, and thus, can have a negative impact on performance. It can be concluded that there is a significant relation between melatonin, zinc, and physical performance.

Keywords: melatonin, exercise, zinc, glycogen, lactic acid

Introduction

Melatonin is a neuro-hormone secreted from the pineal gland and involved in various regulatory activities in body. Ever-increasing use of melatonin supplements and enlarging research evidences make the authors undertake the review to arrive at a qualitative conclusion of whether melatonin supplements can act as potential treatment options or not. Melatonin has been used successfully in chronic insomnia and as an anti-oxidant in cancer and other age-related neuro-degenerative disorders, especially Alzheimer's disease and Autistic disorders. Its evidences of use in other conditions remained insufficient and inconclusive. Because stress, especially traumatic stress, has been identified a significant factor in pathogenesis of mental disorders, together these findings suggest that melatonin alterations represent an important neuroendocrinologic marker of psychopathological processes and stress-related cognitive dysfunctions. Melatonin represents the biological clock which significantly influences encoding and contextual binding in memory processes and cognition. This

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integrative function of melatonin on many levels of living organisms represents an embodied time that is a major factor of bodily and mental functioning. Recent accumulating evidence also indicates that melatonin and/or its metabolites may slow neurodegenerative processes and show protective effects against stress. Although at this time the relationship between stress and melatonin is only partially understood, the positive influence of melatonin to memory and cognition seems to be particularly promising for further research that may well determine basic relationships and consequences for treatment of mental disorders (Sanchez-Campos et al., 2001; Nduhirabandi, du Toit, & Lochner, 2012).

Moreover, exercise may affect not only expression of circadian rhythm-related genes, but also the level of melatonin. Exercise elicits phase shifts and acute alterations of melatonin that vary with circadian phase reported that exercise conducted at various times might alter the level of melatonin, and that melatonin increased temporarily for approximately 30-80 min following exercise. Melatonin secretion in humans affects the sleep cycle and sleep has been reported to play a crucial role in the condition and recovery of athletes. Last some studies suggest that melatonin supplementation improves antioxidant status and may prove to have beneficial effects preventing DNA damage induced by high intensity training (Hagerman, 1992; Song et al., 2018).

According to the literature, even a single dose of exogenous melatonin administered just before the exercise prevented inflammation, oxidative stress, and muscle damage. It is well documented that exhaustive physical exercise leads to inflammation and skeletal muscle tissue damage (Ortiz-Franco et al., 2017). With this in mind, melatonin has been acutely administered before physical exercise; nevertheless, the use of melatonin as an ergogenic agent to prevent tissue inflammation and damage remains uncertain. Beck et al. (2015) evaluated the effects of melatonin on swimming performance, muscle inflammation and damage, and several physiological parameters after exhaustive exercise at anaerobic threshold intensity (iLAn) performed during light or dark circadian periods. Despite the ergogenic effect of a single melatonin dose just before acute exercise remaining controversial in the literature, our study found significantly enhanced performance in the animals that received this hormone. However, it did not prevent either inflammation or tissue damage resulting from exhaustive exercise.

Melatonin, Zinc, and Exercise

It is argued that melatonin secreted from the pineal gland regulates the levels of zinc, which is an important trace element. Decreases in zinc levels of pinealectomized rats support this relationship. There is an increasing amount of evidence suggesting that the pineal gland can have important effects on physical activity. There are many studies pointing to the relation between melatonin secreted from the pineal gland and zinc, an important trace element.

Zinc is necessary for melatonin synthesis. Melatonin, in turn, increases the absorption of zinc in the digestive system. The decrease observed in zinc levels after pinealectomy can cause muscle exhaustion, and thus, can have a negative impact on performance. It can be concluded that there is a significant relation between melatonin, zinc, and physical performance.

Previously we did a study; the objective of the present study was to explore the changes in serum lactate levels in pinealectomized rats subjected to acute swimming exercise and its relation with zinc. According to this study, the decrease observed in zinc levels after pinealectomy can cause muscle exhaustion, and thus, can have a negative impact on performance. It can be concluded that there is a significant relation between melatonin, zinc, and physical performance (Baltaci, Cumraligil, Kilic, & Kaya, 2007). We were found in another study that results of the study demonstrate that melatonin supplementation can have a protective effect on liver glycogen reserves in rats subjected to acute swimming exercise. We made again study on 30 adult male rats of Spraque-Dawley. Species were allocated to three groups, each containing an equal number of rats: general control group which was not subjected to any procedure (Group 1), the group which was subjected to 30 minutes acute swimming exercise (Group 2), and the group which was subjected to 30 minutes acute swimming exercise after four-week intraperitoneal (i.p.) melatonin (3 mg/kg/day) supplementation. Lactate and zinc levels in the plasma were studied in the blood samples taken from the experimental animals by decapitation method. Results of the study demonstrate that melatonin supplementation to rats subjected to acute swimming exercise reduces lactate levels, thereby delaying exhaustion. Increased zinc levels may be mediating this melatonin effect (see Table 1).

Table 1
Plasma Lactate and Zinc Levels in the Study Groups

Gruplar (*N* = 10)	Lactate (mg/dl)	Zinc (μg/dl)
1. Control	22.99 ± 4.75c	101.80 ± 5.94b
2. Swimming control	61.60 ± 11.90a	90.10 ± 6.45c
3. Melatonin-supplemented swimming	50. 45 ± 14.13b	124.30 ± 6.13a

Note. * Differences between means with different superscripted letters in the same column are statistically significant ($p < 0.05$) (Kaya et al., 2006a; 2006b).

Mazepa, Cuevas, Collado, and González-Gallego (2000) have shown in a study that exercise results in a significant increase in plasma and liver lactate levels of experimental animals, while melatonin supplementation brings about a significant decrease in both plasma and liver lactate levels. The results that Mazepa et al. obtained not only demonstrate that melatonin supplementation can delay exhaustion by significantly reducing lactate levels, but also support our findings.

Discussion

The increase in glycogen stores is a major factor determining the performance in moderate and prolonged aerobic exercise and, in consequence, is considered the most important limiting factor for performance in endurance. It can be concluded that there is a significant relation between melatonin, zinc, and physical performance (Bergstrom, Hermansen, Hultman, & Saltin, 1967). Mazepa et al. (2000) demonstrated that melatonin protects the glycogen stores and that glycogen content (muscle and liver) increases in melatonin-treated exercised animals compared with sedentary ones. Other studies have also demonstrated that supplementation with melatonin before exercise preserves glycogen stores, maintains blood glucose, and lowers plasma and liver lactate. From the data reviewed here, it is clear that the exercise—melatonin interplay may have a favorable influence over many systems in the body. Results of the study demonstrate that melatonin supplementation to rats subjected to acute swimming exercise reduces lactate levels, thereby delaying exhaustion. Increased zinc levels may be mediating this melatonin effect. More information on exercise and melatonin, however, is necessary to explain some contradictory findings in the literature (Kaya et al., 2010).

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