Chapter 1

Magnesium Supplementation on Athletes

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Abstract

This review aimed to evaluate, through randomized trials, the effects of magnesium supplementation on stress management, blood pressure, strength, aerobic performance, anaerobic performance and muscle soreness of athletes.

An electronic search was performed on the PubMed, from the year of 2000 until December 2021. Studies were eligible if 1) the only supplementation considered was Magnesium ;2) participants were only recreation and/or competition athletes; 3) the study design was a randomized trial (randomized controlled study or randomized cross-over study); 4) studies from the year 2000 onwards. This review demonstrates that 1) magnesium supplementation had efficacy on the reduction of anxiety before a game and levels of stress 24 hours after a game; 2) acute load (1 week) of magnesium supplementation improves systolic and diastolic blood pressure of athletes while chronic load (4 weeks) of magnesium supplementation only improves systolic blood pressure; 3) acute load (1 week) magnesium supplementation improves the strength of athletes while chronic load (4 weeks) of magnesium supplementation had no effect; 4) neither acute (1 week) nor chronic load (4 weeks) of magnesium supplementation had effect on aerobic performance of athletes; 5) chronic load (4 weeks) of magnesium supplementation improves anaerobic alactic performance of athletes contrary to no effects on anaerobic lactic performance; 6) acute load (1 week) of magnesium supplementation improves muscle soreness.

Keywords: Magnesium; Supplementation; Athletes.

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1. Introduction

Magnesium is a widely recognized nutrient, with a crucial role in athlete performance. It is involved in numerous physiological mechanisms that influence energy production, improve the functionality of immune system, modulates pain and contributes to boné health and muscle function [1]. However, several studies indicates the existance of a considerable percentage of athletes from different sports with magnesium deficiency [1-3] as athletes are more susceptible to magnesium deficiency due increased energy expenditure [1]. To bridge this gap, magnesium supplementation can be a solution [4]. Nevertheless, it lacks robust scientific evidence regarding the benefits of magnesium supplementation on athletes. According to Hariton & Locascio (2018) [5], randomized trials are the gold standard for scientific research. Thus, the aim of this review is to evaluate, through randomized trials, the effects of magnesium supplementation on the evolution of different outcomes on athletes.

2. Methods

2.1. Search strategy

An electronic search was made by one author [CV] in the database "PubMed", from the year of 2000 until December 2021, to identify articles assessing the effects of magnesium supplementation on athletes. For database search, the following descriptors were used: (magnesium[Title]) AND (physical activity[Title] OR exercise[Title] OR athletes[Title] OR players [Title] OR performance [Title]).

2.2. Selection of the studies

One author [CV] reviewed the search results and screened publications provided by database (Pubmed) on February 2022, according to the following steps: 1) articles were selected by the information from title and abstract; 2) full text analysis of potentially relevant articles was done to determine their eligibility for this review.

Studies were considered eligible if: 1) the only supplementation considered was Magnesium ;2) participants were only recreation and/or competition athletes; 3) the study design was a randomized trial (randomized controlled study or randomized cross-over study); 4) studies from the year 2000 onwards.

Studies were excluded according to the following criteria: 1) Magnesium was not the only supplementation considered; 2) participants were not recreation and/or competition athletes; 3) the study design was not a randomized trial; 4) studies before the year of 2000.

2.3. Data extraction

Each selected article was screened by the author to extract information regarding: (1) study characteristics (first author, year of publication, country); (2) study purpose; (3) study design; (4) participants characteristics (including sample size and mean age ± standard deviation); (5) description of interventions; (6) main findings of the outcomes measured.

2.4. Data analysis

For each study, the differences in the evolution of one or more of the following outcomes were analyzed: indicators of stress management, blood pressure, strength, aerobic performance, anaerobic performance and/or muscle function.

3. Results

3.1. Study selection

A total of 239 references were identified in the initial search. After screening for title and abstract, 235 papers were excluded because of: 1) being reviews; 2) non-randomized trial study; 3) participants were non-athletes; 4) magnesium was not the only supplement on intervention group; 5) studies related with magnesium biodegradable materials; 6) animal studies and 7) non longitudinal studies. Thus, in final analysis 4 studies were included in this review.

3.2. Study characteristics

Table 1 described the detailed data from randomized cross over studies regarding the effects of magnesium supplementation on athletes.

Table 1: Randomized cross over studies regarding the effects of magnesium supplementation on athletes.

Authors / Country	Study purpose	Study design	Participants (N); mean age (years ± SD)	Intervention on both groups	Main findings
Kass et al. (2015) [6] / United Kingdom	Assess the effect of acute vs.chronic oral magnesium supplementation on resistance exercise and vascular response on recreational athletes	Randomized crossover trial	Acute intervention group: N = 6; 35.8 ± 6.2 Chronic intervention group: N = 7; 40.8 ± 4.4	**Acute intervention group**: 300 mg/day of elemental magnesium for 1 week. **Chronic intervention group:** 300 mg/day elemental magnesium for 4 weeks	- Acute magnesium loading improved net strength, while no significant differences (p =0.031) were noticed on chronic magnesium loading. magnesium (p =0.281) - Acute supplementation magnesium significantly reduced systolic and diastolic blood pressure post-exercise, whilst magnesium chronic loading strategy significantly reduced systolic blood pressure, while no changes were noticed on diastolic blood pressure

Steward et al. (2019) [7] / United Kingdom	Assess the efect of magnesium intake on physiological responses and performance during eccentric exercise and recovery	Randomized crossover trial	N = 9; 27.0 ± 4.0	**Placebo group:** Low magnesium diet supplemented with placebo capsules during 7 days **Supplementation group:** Low magnesium diet supplemented with 500 mg/day of magnesium during 7 days	Magnesium supplementation reduced the IL-6 response, enhanced recovery of blood glucose, and muscle soreness after strenuous exercise, but did not improve performance or functional measures of recovery.

Table 2 described the detailed data regarding the randomized controlled trials.

Table 2: Randomized controlled trials regarding the effects of magnesium supplementation on athletes.

Authors/ Country	Study purpose	Study design	Participants (N); mean age (years ± SD)	Intervention on both groups	Main findings
Dmitrasinovic et al. (2016) [8] / Serbia	Assess if chronic magnesium supplementation reduce damaging stress effects in amateur rugby players	Randomized controlled trial	CG: N = 10; 22.9 ± 1.2 IG: N = 13; 23.6 ± 1.4	**Control Group:** No intervention **Intervention Group:** During 28 days, players received 500 mg of magnesium, divided in two doses, twice a day with a 12 h interval between doses of 250 mg (Magnesium 250 mg ®, Natural Wealth®, NBTY Inc.)	There was a statistically significant increase in plasma ACTH concentration in intervention group compared to control group, while reductions in cortisol concentrations between the two groups were the greatest at the day of competition ($p<0.01$) and 1 day before the competition ($p<0.01$). Magnesium supplementation impaired the increase in IL-6 level verified in control group on the day after the game.
Setaro et al. (2014) [9]/Brazil	Assess if 4 weeks of magnesium supplementation influences the physical performance of volleyball players	Randomized controlled trial	CG: N = 13; 17.9 ± 1.0 IG: N = 12; 17.4 ± 1.6	**Control Group:** 500 mg/day of maltodextrin during 4 weeks **Intervention Group:** 350 mg/day of magnesium during 4 weeks	Significant differences between groups in the countermovement jump with arm swing, with a higher increase on intervention group compared to control group ($p = 0.034$)

In the study of Kass et al. (2015) [6], these authors aimed to assess the effect of oral magnesium supplementation (acute vs. chronic loading strategy) on resistance exercise and vascular response after intense exercise on 13 recreational athletes.

For acute loading strategy (1 week 300 mg/day magnesium supplementation):

- the results on bench press showed a significant increase of 17.7% ($p = 0.031$) on day 1 and no change in performance on day 2 post exercise .

- on day 2 post-exercise, systolic and diastolic blood pressure were significantly lower (p = 0.0.47 for both measures)

- peripherical resistance reduced on days 1 and 2 ($p = 0.031$).

In what concerns the chronic loading strategy (4 weeks 300 mg/day magnesium supplementation), results showed:

- performance on bench press decreased 32.1%.

- on day 2 post-exercise, systolic blood pressure was significantly lower (p = 0.0.16 for both measures), whilst diastolic blood pressure had no changes.

- peripherical resistance increased on day 1 ($p = 0.008$) and no changes were noticed on day 2.

In the study of Steward et al. (2019) [7], these authors aimed to investigate the effect of magnesium intake on physiological responses and performance during eccentric exercise and recovery on nine male recreational runners.

Participants consumed low magnesium diets and were supplemented with 500 mg/day of magnesium (intervention group) or placebo (control group) for 7 days prior to a 10 km downhill running time trial (separated by a 2-week washout period).

At baseline and 24 h post running time trial, maximal muscle force was measured. Interleukin-6 (IL-6) and creatine kinase (CK) were measured at rest, 0 h, 1 h and 24 h post running time trial. Muscle soreness was measured at the previous times plus 48 h and 72 h post. Glucose and lactate were measured during the running time trial.

There was a significant decrease on IL-6 response and muscle soreness on intervention group when compared to control group between intervention and control group ($p < 0.05$ and $p < 0.01$ respectivelly). Recovery of blood glucose and muscle soreness were enhanced on intervention group post running time trial. There were no diferences in glucose and lactate during the running time trial, or post measures of CK and maximal muscle force.

In the study of Dmitrasinovic et al. (2016) [8], authors aimed to assess if chronic magnesium supplementation is effective on the reduction of damaging stress effects in 23 amateur rugby players. Participants from intervention group received a 4 week magnesium supplementation, composed of 500 mg of magnesium twice a day with 12 hours of interval between doses. Participants from control group had no magnesium supplementation. To evaluate ACTH, cortisol and IL-6 levels, blood and saliva sampling were collected in different times towards a rugby game: 1 day before; in the morning before the match; 1 day, 3 days and 6 days after the match. There was a statistically significant increase in ACTH concentration in intervention group compared to control group, while reductions in cortisol concentrations between the two groups were the greatest at the day before the game ($p<0.01$) and at the day of the game, before it starts ($p<0.01$). Results also showed that magnesium impaired the increase in IL-6 level noted in control group on day after the game.

In the study of Setaro et al. (2014) [9], these authors assessed the influence of a 4-week magnesium supplementation on physical performance of 25 volleyball players. Participantes from intervention group were supplemented with 350 mg/day of magnesium during 4 weeks, while participants from control group received a capsule of 500 mg/day of maltodextrin during the same time. Maximal oxygen uptake; neuromuscular capabilities; dynamic muscle function and lactate production were assessed at baseline and at 4 weeks. The results of this study showed that there was a significant decrease in lactate production ($p = 0.001$) and significant increase (of up to 3 cm) in countermovement jump ($p = 0.002$) and countermovement jump with arm swing values ($p < 0.001$) in the experimental group. No significant differences were found on intervention group neither between groups on VO2 max ($p = 0.691$ and $p = 0.490$ respectivelly). Only countermovement jump with arm swing had a significant increase on intervention group when compared to control group ($p = 0.034$).

4. Discussion

4.1. Stress management

Literature support the interaction of magnesium with key mediators of the physiological stress response, but the exact mechanisms underlying these effects are not so clear yet [10]. One possible explanation is given by Murck (2002) [11] that refers that Mg ion has N-methyl-D-aspartate - antagonistic and gamma-aminobutyric acid - agonistic properties. According to this author, this fact contributes to the reduction of the level of anxiety. Magnesium deficiency contributes to the C-reactive protein rise [12], phagocyte activation and consequently to higher cytokine production [13].

In the study of Dmitrasinovic et al. (2016) [8], the most significant results regarding the effect of magnesium supplementation on stress management were noted before the game, with rugby players being less susceptible to anxiety. This result demonstrate the crucial role of this mineral in the reduction of anticipating anxiety.

According to Frank et al. (2013) [14], stress increases circulating levels of interleukin-6 (IL-6). Studies conducted on athletes not submitted to magnesium supplementation showed signifiicant increase of post-exercise IL-6 levels, especially 24 hours after the game ended (Cunniffe et al., 2010) [15]. In the study of Dmitrasinovic et al. (2016) [8], the rise in IL-6 level after a rugby match that was observed in the control group was hindered in the group with magnesium supplementation. The same result was found in the study of Steward et al. (2019) [7] with recreational endurance runners after a 10km downhill running with previous one week 500mg/day magnesium supplementation.

4.2. Blood pressure

On literature the effects of magnesium supplementation on the reduction of blood pressure levels on non-athletes are already stated, both in healthy subjects [16, 17] and on subjects with non-communicable diseases [18].

According to literature, there are two main mechanisms that explain the interaction of Magnesium and blood pressure. One mechanism is explained by Bara et al. (1993) [19], who referred that magnesium has the ability to mobilize more sodium to be excreted by urine as it increases the sodim potassium pump in the cell membrane. This reduction of intracellular sodium may cause the relaxation of the smooth muscle cells and consequently the reduction of blood pressure. Another mechanism is presented by Touyz (2004) [20] that emphasize the importance of magnesium as a calcium channel blocker, that leads to na increase of arterial compliance and concurrently to the reduction of blood pressure.

In the study of Kass et al. (2015) [6], magnesium acute supplementation (1 week 300 mg/day magnesium) significantly reduced systolic and diastolic blood pressure post-exercise, whilst magnesium chronic loading strategy (4 weeks 300 mg/day magnesium) significantly reduced systolic blood pressure, while no changes were noticed on diastolic blood pressure.

4.3. Strength

Previous studies on non-athletes [21] and athletes [22, 23] reported that magnesium supplementation had a positive effect on strength performance.

According to Dominguez et al. (2006) [21], this strength increase is related to physiological-regulatory functions of magnesium during muscle function (contraction plus relaxation), such as the regulation of troponin expression via calcium concentration gradientes; greater amount of actin-mysoin crossbridges.

In the study of Kass et al. (2015) [6], these authors found that acute magnesium loading (1 week) improved net strength, while no significant differences were noticed on chronic magnesium loading (4 weeks). According to the same authors, the inexistence of an acumulative effect suggests a regulatory effect within the body influenced by the duration of magnesium supplementation intake.

On the study of Setaro et al. (2014) [9], peak torque and potency had no changes between groups after 4 weeks of 350 mg/day magnesium supplementation.

4.4. Aerobic performance

According to Kass et al. (2015) [6], the effects of magnesium supplementation on resistance exercise has not yet scientific evidence.

On the study of Steward et al.(2019) [7], magesium supplementation for 1 week did not improve aerobic performance on recreational endurance runners, while on the study of Setaro et al. (2014) [9], there were no significant differences between groups on aerobic performance of volleyball players, after 4 weeks of 350 mg/day magnesium supplementation on intervention group. These findings are in accordance with previous studies that concluded that magnesium supplementation does not enhance aerobic performance in the context of a single bout of acute exercise in young athletic individuals [24, 25].

4.5. Anaerobic performance

According to Cahill et al. (1997) [26], anaerobic energy system is related to high-intensity training. On many team sports, this energy system is constantly required, as for example on many Volleyball technical skills that required vertical jumping, such as spiking, blocking, serving, setting. On the study of Setaro et al. (2014) [9], 4 weeks of 350 mg/day magnesium supplementation significantly improved countermovement jump with arm swing when compared to participants from control group. Despite no significant differences between groups, countermovement jump significantly increase on intervention group contrary to no significant differences on control group. According to Setaro et al. (2014) [9], these results can be explained by the interconnection between the higher supply of magnesium and the more energy is produced for movements of short duration and high intensity, as vertical jumps. Besides, magnesium is a cofactor for creatine kinase, a crucial enzyme of anaerobic alactic system that had tendency to increase in plasma after strenuous physical activity [27].

On the supracited study, contrary to anaerobic alactic performance, the anaerobic lactic performance was not changed.

4.6. Muscle function

In the study of Steward et al. (2019) [7], magnesium supplementation (1 week of 500 mg/day) did not change values of blood glucose neither blood lactate during exercise, but increased blood glucose 1–24 h post-exercise, and reduced muscle soreness 24–72 h after the exercise.

Regarding changes on blood glucose and blood lactate during exercise, Chen et al. (2014) [28] and Cheng et al. (2010) [29] detected significant improvements after magnesium supplementation. As in the study of Chen et al.(2014) [28] it was concluded that higher doses of magnesium supplementation induces better resuts, 500 mg/day of magnesium may be an insufficient dose to achieve significant results. However, in humans, according to Portalatin & Winstead (2012) [30], higher doses (>500 mg/day) should be taken with very carefull given the well-established laxative and gastrointestinal side efects of higher doses of this mineral.

In what concerns muscle soreness, De Jongh et al. (2003) [31] refers the interrelationship between IL-6 and the perception of pain. However, Steward et al.(2019) [7] found no relationship between IL-6 and muscle soreness. Thus, the mechanism responsible for the decrease on muscle soreness remains to be found.

5. Conclusion

On the few randomized studies that were found on literature, we can conclude that:

1) Magnesium supplementation had efficacy on the reduction of anxiety before a game and levels of stress 24 hours after a game

2) Acute load (1 week) of magnesium supplementation improves systolic and diastolic blood pressure of athletes. Chronic load (4 weeks) of magnesium supplementation only improves systolic blood pressure.

3) Acute load (1 week) magnesium supplementation improves the strength of athletes while chronic load (4 weeks) of magnesium supplementation had no effect.

4) Neither acute (1 week) nor chronic load (4 weeks) of magnesium supplementation had effect on aerobic performance of athletes.

5) Chronic load (4 weeks) of magnesium supplementation improves anaerobic alactic performance of athletes contrary to no effects on anaerobic lactic performance.

6) Acute load (1 week) of magnesium supplementation improves muscle soreness

There is an urgent need for more robust studies (randomized trials), with a larger sample size and different magnesium supplementation protocols to establish a cause-effect relationship between magnesium supplementation and the different outcomes that can be influcenced by this mineral.

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6. References

1. Pollock N, Chakraverty R, Taylor I, Killer SC. An 8-year Analysis of Magnesium Status in Elite International Track & Field Athletes. J Am Coll Nutr. 2020;39(5):443-449. doi:10.1080/07315724.2019.1691953

2. Heaney S, O'Connor H, Gifford J, Naughton G. Comparison of strategies for assessing nutritional adequacy in elite female athletes' dietary intake. Int. J. Sport Nutr. Exerc. Metab. 2010; 20:245Y56. doi:10.1123/ijsnem.20.3.245

3. Silva MR, Paiva T. Low energy availability and low body fat of female gymnasts before an international competition. Eur J Sport Sci. 2015;15(7):591-599. doi:10.1080/17461391.2014.969323

4. Zhang Y, Xun P, Wang R, Mao L, He K. Can Magnesium Enhance Exercise Performance?. Nutrients. 2017;9(9):946. doi:10.3390/nu9090946

5. Hariton E, Locascio JJ. Randomised controlled trials - the gold standard for effectiveness research: Study design: randomised controlled trials. Bjog. 2018;125(13):1716. doi: 10.1111/1471-0528.15199

6. Kass LS, Poeira F. The effect of acute vs chronic magnesium supplementation on exercise and recovery on resistance exercise, blood pressure and total peripheral resistance on normotensive adults. J Int Soc Sports Nutr. 2015; 12:19. doi:10.1186/s12970-015-0081-z

7. Steward CJ, Zhou Y, Keane G, Cook MD, Liu Y, Cullen T. One week of magnesium supplementation lowers IL-6, muscle soreness and increases post-exercise blood glucose in response to downhill running. Eur J Appl Physiol. 2019;119(11-12):2617-2627. doi:10.1007/s00421-019-04238-y

8. Dmitrašinović G, Pešić V, Stanić D, Plećaš-Solarović B, Dajak M, Ignjatović S. ACTH, Cortisol and IL-6 Levels in Athletes following Magnesium Supplementation. J Med Biochem. 2016;35(4):375-384. doi:10.1515/jomb-2016-0021

9. Setaro L, Santos-Silva PR, Nakano EY, et al. Magnesium status and the physical performance of volleyball players: effects of magnesium supplementation. J Sports Sci. 2014;32(5):438-445. doi:10.1080/02640414.2013.828847

10. Pickering G, Mazur A, Trousselard M, et al. Magnesium Status and Stress: The Vicious Circle Concept Revisited. Nutrients. 2020;12(12):3672. doi:10.3390/nu12123672

11. Murck H. Magnesium and affective disorders. Nutr Neurosci. 2002;5(6):375-389. doi:10.1080/1028415021000039194

12. King DE. Inflammation and elevation of C-reactive protein: does magnesium play a key role? Magnes Res 2009; 22: 57–9.

13. Libako P, Nowacki W, Rock E, Rayssiguier Y, Mazur A. Phagocyte priming by low magnesium status: input to the enhanced inflammatory and oxidative stress responses. Magnes Res 2010; 23: 1–4. doi:10.1684/mrh.2009.0201.

14. Frank M.G, Watkins L.R, Maier S.F. Stress-induced glucocorticoids as a neuroendocrine alarm signal of danger. Brain Behav. Immun 2013; 33, 1-6. doi:10.1016/j.bbi.2013.02.004

15. Cunniffe B, Hore AJ, Whitcombe DM, Jones KP, Baker JS, Davies B. Time course of changes in immuneoendocrine markers following an international rugby game. Eur J Appl Physiol 2010; 108: 113–22. doi:10.1007/s00421-009-1200-9

16. Jee SH, Miller ER 3rd, Guallar E, Singh VK, Appel LJ, Klag MJ. The effect of magnesium supplementation on blood pressure: a meta-analysis of randomized clinical trials. Am J Hypertens. 2002;15(8):691-696. doi:10.1016/s0895-7061(02)02964-3

17. Kass L, Weekes J, Carpenter L. Effect of magnesium supplementation on blood pressure: a meta-analysis. European Journal of Clinical Nutrition 2012; 66(4), 411-418. doi:10.1038/ejcn.2012.4

18. Dibaba DT, Xun P, Song Y, Rosanoff A, Shechter M, He K. The effect of magnesium supplementation on blood pressure in individuals with insulin resistance, prediabetes, or noncommunicable chronic diseases: a meta-analysis of randomized controlled trials. Am J Clin Nutr. 2017;106(3):921-929. doi:10.3945/ajcn.117.155291

19. Bara M, Guiet-Bara A, Durlach J. Regulation of sodium and potassium pathways by magnesium in cell membranes. Magnes Res. 1993;6(2):167-177.

20. Touyz, R.M. Magnesium in clinical medicine. Front Biosci. 2004; 9: 1278-1293. doi:10.2741/1316

21. Dominguez LJ, Barbagallo M, Lauretani F, Bandinelli S, Bos A, Corsi AM, et al. Magnesium and muscle performance in older persons: the InCHIANTI study. Am J Clin Nutr. 2006;84:419–26. doi:10.1093/ajcn/84.1.419

22. Santos DA, Matias CN, Monteiro CP, et al. Magnesium intake is associated with strength performance in elite basketball, handball and volleyball players. Magnes Res. 2011;24(4):215-219. doi:10.1684/mrh.2011.0290

23. Matias CN, Santos DA, Monteiro CP, Silva AM, Raposo MDF, Martins F, et al. Magnesium and strength in elite judo athletes according to intracellular water changes. Magnes Res. 2010;23:138–41. doi:10.1684/mrh.2010.0217

24. Terblanche S, Noakes TD, Dennis SC, Marais D, Eckert M. Failure of magnesium supplementation to influence marathon running performance or recovery in magnesium-replete subjects. Int J Sport Nutr. 1992;2(2):154-164. doi:10.1123/ijsn.2.2.154

25. Finstad EW, Newhouse IJ, Lukaski HC, Mcauliffe JE, Stewart CR. The effects of magnesium supplementation on exercise performance. Med Sci Sports Exerc. 2001;33(3):493-498. doi:10.1097/00005768-200103000-00024

26. Cahill BR, Misner JE, Boileau RA. The clinical importance of the anaerobic energy system and its assessment in human performance. Am J Sports Med. 1997;25(6):863-872. doi:10.1177/036354659702500623

27. Uchida MC, Nosaka K, Ugrinowitsch C, et al. Effect of bench press exercise intensity on muscle soreness and inflammatory mediators. J Sports Sci. 2009;27(5):499-507. doi:10.1080/02640410802632144

28. Chen HY, Cheng FC, Pan HC, Hsu JC, Wang MF. Magnesium enhances exercise performance via increasing glucose availability in the blood, muscle, and brain during exercise. PLoS One. 2014;9(1):e85486. doi:10.1371/journal.pone.0085486

29. Cheng SM, Yang LL, Chen SH, Hsu MH, Chen IJ, Cheng FC. Magnesium sulfate enhances exercise performance and manipulates dynamic changes in peripheral glucose utilization. Eur J Appl Physiol. 2010;108(2):363-369. doi:10.1007/s00421-009-1235-y

30. Portalatin M, Winstead N. Medical management of constipation. Clin Colon Rectal Surg. 2012;25(1):12-19. doi:10.1055/s-0032-1301754

31. De Jongh RF, Vissers KC, Meert TF, Booij LHDJ, De Deyne CS, Heylen RJ. The role of interleukin-6 in nociception and pain. Anesth Analg. 2003; 96(4):1096-1103. doi:10.1213/01.ANE.0000055362.56604.78