ECRONICON OPEN ACCESS

EC EMERGENCY MEDICINE AND CRITICAL CARE
Review Article

Morning Vs Evening Exercises: Which Gives A Better Outcome?

WMMS Bandara* and AJIS Rathnayake

Department of Pre-clinical Sciences, Faculty of Medicine, General Sir John Kotelawala Defence University, Kandawala Road, Ratmalana, Sri Lanka

***Corresponding Author**: WMMS Bandara, Department of Pre-clinical Sciences, Faculty of Medicine, General Sir John Kotelawala Defence University, Kandawala Road, Ratmalana, Sri Lanka.

Received: July 16, 2019; **Published:** July 29, 2019

Abstract

Regular physical exercises (RPE) improve health parameters. The effectiveness of RPE on physiological, biochemical and psychological health parameters is determined by number of factors. In addition to intensity and duration of exercises, time of the day that exercises are performed has shown to play an important role in this regard. Variations in the outcome of morning exercises vs evening exercises have been reported by many researches. Here, we discuss the findings of published research and describe the time of day effect of exercises on fitness and health. Furthermore, possible reasons for observed effects of timing of exercises are discussed with considerations for future research in the field. The present review highlights the importance of having clear understanding regarding time of the day effect on exercises to obtain maximum benefit for scientists, physical trainers, sports man as well as general public who engages in RPE among their busy schedules.

Keywords: *Exercise; Health Parameters; Time of the Day Effect*

Introduction

Psychological disorders, obesity, diabetes and cardiovascular diseases have become risk factors for mortality and morbidity [1-3]. Sedentary life style and stress during day-today life have been identified as one of the major causes that affect metal health as well as overall health [4]. It has been found that 75-90% of visits to primary health care physicians are due to stress associated health concerns [5]. Depression, anxiety, headaches, back and neck pain, sleep problems are commonly associated with stress [6]. Additionally, stress and inactive urban life style have become a risk factor for, obesity, diabetes and cardiovascular diseases [7-9].

Though stress has survival advantages [10], prolong exposure to stress induces unfavorable alterations in health related parameters [11]. Sleeping habits, drug use and the dietary habits may be affected undesirably due to increased stress [6,12]. According to the report published by the American Psychological Association in 2011, over-eating or eating unhealthy food with missing meals is a common behavioral change seen in stressed individuals [13]. The report also states that nearly half of the respondents had sleeping changes due to stress [13]. Moreover, altered levels of hormones, neurotransmitters etc. have been reported in stressed individuals causing unfavorable changes in the metabolic processes [14]. As the current urban life styles are heavily stress inducible, means of stress reduction have drawn attention and effective methods with prolong stress reducing effects are under investigation [15].

Carrying out regular physical exercises (RPE) is well known to have favorable effects on health [16-18]. Consistent results have been reported by many groups with favorable alterations in the physiological and biochemical parameters after RPE [16-18]. RPE have been shown to increase the functional capacity and the quality of life of a person with positive influence on cardio-metabolic risk factors [16,18].

RPE also maintains appropriate body weight, body mass index (BMI), relative body fat content and composition, size, strength and flexibility of muscles[19]. Exercises are known to have favorable effects on respiratory system increasing aerobic capacity, oxygen uptake and oxygen transport [20]. Engagement in aerobic exercises improves peak maximal oxygen consumption (VO2max) [20]. Furthermore, increased heart rate and stroke volume with increased blood flow have complimentary effects on cardiovascular system [21,22]. The favorable alterations in biochemical parameters after physical exercises have been observed by us and other groups previously [16,18,23].

RPE have shown to reduce stress levels [24]. Cortisol secreted by adrenal cortex acts in response to stressors thus considered as a marker of elevated stress levels [25,26]. Inverse relationship between blood cortisol levels and exercises has been found by many researches [16,27,28]. Calming effects with good sleep after adequate exercises that lasts for several hours have been reported [14]. Many studies have shown inverse associations between physical exercises and depression [29,30]. Furthermore, it has been shown that reduced physical activity results in emerging depression [31]. Research has shown that physical exercises lower the risk of dementia and cognitive decline [32].

The existing guidelines recommend at least 2.5 hours of moderate exercises or 1.25 hours of vigorous-intensity exercises per week. Resistance exercises are recommended for 2-3 days per week for additional health benefits [33]. The recommendations on exercises are based on published research [34-38] thus, it is essential to review the current research and analyze the data from different ethnic groups before drawing conclusions. Many reviews have been published combining isolated research data giving insights into the current understanding of the effect of exercises [39-42]. We have previously reviewed the effect of duration of physical exercises on biochemical parameters which analyzed data from research derived from South Asian cohorts [43].

In addition to the intensity and duration of exercises, one of the factors that can affect the outcome of the exercises is the time of the day that the exercises are performed. Research from many groups have shown varied effects of the time-of-day on exercises [44,45]. Therefore, the beneficial outcomes of exercises on biochemical and physiological health parameters, overall health and disease may depend on the time of day the exercises are performed. There have been studies that compare the effects of morning vs evening exercises [46-81]. Here in this review we summarize the "time of day effects" of exercises on fitness and health.

Morning vs evening exercises: Morning is better

Hobson., *et al*. examined the effects of the time of the day on improving aerobic exercise capacity [46]. The investigators demonstrated that the strength of exercise capacity of men participated in the study during thorough cycling exercise and VO_2 max is significantly higher when the exercises are performed in the morning than in the evening [46]. Consistently, Brisswalter., *et al*. also observed increased VO_2max after moderate exercise performed in the morning than evening [47]. A study identified that "morning is better for exercises" was published in 2011 by Fairbrother., *et al*. [48]. In their experiment, moderate exercises were performed on three pre-hypertensive groups aged 40 - 60, where each participant was subjected to graded exercise test with subsequent walk on a treadmill for 30 minutes, three times a week at three different times of the day: 7 am, 1 pm and 7 pm [48]. They assessed the blood pressure levels and sleep patterns. It was found out that the group who exercised at 7 in the morning showed 10% reduction in blood pressure and a 25% drop in nocturnal systolic blood pressure than the other two groups who exercised at 1 pm and 7 pm. Furthermore, morning exercises showed improvements in sleeping with longer and deeper sleep compared to the groups that exercised at other times [48]. In the sleep analysis it was revealed that the morning exercised group spent 75% more time in the deep sleep. Changes in sleep behavior also improved in other health parameters such as cardiovascular health, stress and anxiety [48]. The authors concluded that morning is the best time for aerobic exercises with beneficial effects on blood pressure at night and quality of sleep [48].

Reduction in levels of catecholamines, cor¬tisol and other stress hormones have been shown in relation with the improved nighttime blood pressure changes with improved parasympathetic activity [49,50]. After morning exercises it has been shown that the cortisol levels decline across the day [51]. Immediate effect on cortisol levels after exercises seems to be independent of the time of the day showing similar levels of blood cortisol levels in both the morning and evening exercised groups [52-55].

The time of the day effects of exercises on muscular system have also been studied [56-58]. Sedliak and colleagues experimented on the effect of "time-of-day-specific training" on isometric strength of young men [56]. Their study groups underwent specific training for period of ten weeks either in the morning (7 - 9 am) or in the late evening (5 - 7 pm). It was shown that morning exercises improve isometric strength better than evening exercises [56]. Lricollais., *et al*. demonstrated that, 60 second Wingate test shows lower muscle fatigue in the evening exercised group than the morning exercised group [57]. Maraki., *et al*. in 2005, found out that higher rates of exertion is observed in morning exercises compared to that of the af¬ternoon during warm up and resistance train¬ing [58]. Alizadeh and colleagues identified moderate- to high-intensity aerobic exercises being more effective when done in the morning than evening in controlling weight and calorie intake [44]. It has been shown that the morning RPE improves sleep quality with easier to fall asleep and sleep duration [59].

Morning vs evening exercises: Evening is better

Studies have shown that the outcome of the physical activity is greater when it is performed in the evening [60-75].

When compared the aerobic work capacity of athletes after a test performed on work meter bike the group that performed in the evening showed 5% more aerobic work capacity than the morning group [60]. Later, same research group revealed that high-intensity training for 5 weeks had a greater work capacity compared to the morning exercise training [61]. After 8 weeks of morning or evening exercises, the group exercised in the evening showed more increase in aerobic and anaerobic power compared to the morning exercised group [61]. In another study, Tori., *et al.* investigated the effects of 4 weeks of aerobic exercise program [62]. The study was done on 3 groups of males who underwent 30 minutes exercise program in three different times of the day: morning (9 am), afternoon (3 pm) and night (8 pm). The data of afternoon exercised group demonstrated significant increase in their VO_2 max, with a significant blood lactic acid level than the other two groups [62]. The authors suggested that afternoon is better time for aerobic exercises [62]. Another research carried out by Rahmaninia and Mirzaei (2002) on young wrestlers also reported a favorable difference in the aerobic power in the evening group but the difference was not significant [63]. Heart rate and performance time have shown to be increased by the evening exercises in a study done by Burgoon., *et al.* [64]. A study has shown that systolic and diastolic pressures significantly increased in participants who underwent physical exercises in the morning from 9.00 - 10.15 am and significantly decreased in participants who conducted physical exercise in the afternoon from 1.30 - 2.45 pm [65]. Faisal., *et al.* also reported similar findings confirming the presence of time-of-day effects of aerobic exercises [66]. After cycling exercises performed in the morning (7 am) and evening (5 pm) Faisal and colleagues concluded that circadian rhythm work closely with priming exercises to decrease blood pressure with greater effect in the evening and with increased skin blood flow [66]. Furthermore, Hill., *et al.* have shown that oxygen uptake was faster when the exercises are performed in the evening, with slower consumption of the anaerobic capacity highlighting the importance of time of the day effect on RPE [67]. Moreover, it has been shown that evening exercises avert the body temperature decline in the night [68].

Chtourou., *et al.* in 2011, performed 30s high intensity cycling exercise in the morning (7 am) or evening (5 pm). Increased muscular power and fatigue were observed in the evening group during the first 20 seconds of the exercise compared to that of morning group [69]. A similar findings was observed by Nicolas., *et al.* in a study carried out to investigate the time-of-day effects on mechanical and myoelectric properties of muscle during isokinetic exercise [70]. A higher contractile capacity was observed with a higher muscle fatigue in the evening compared to the morning [70].

Yoshida., *et al.* stated that 1 hour exercise performed at 8 pm gives better sleep with lower day time sleepiness than morning (7.40 am) evening (4.30 pm) exercises [71]. It has been observed that peak cortisol levels after exercise were highest at 7am compared to evening and late night with lowest cortisol concentrations at 5 pm [72].

It has been found that afternoon exercises is more effective in improving glucose levels in the blood in than morning exercises in type 2 diabetic patients [71]. Another study that tested hormones and inflammatory cytokine levels after exercises revealed that plasma IL-6 and adrenaline concentrations are increased in the blood after evening endurance exercises than morning [72]. Furthermore, free fatty

acid concentrations were elevated in those who underwent evening exercises when compared to the morning group [73]. Consistently, lipid oxidation has been shown to increase after evening exercises than morning [74].

Morning vs evening – No difference

Some research provides evidence to show that both morning and evening exercises have similar effects on health. Passos., *et al.* stated that both morning or evening moderate anaerobic exercises improve quality of sleep and life with improved mood in insomnic patients with no significant correlation between the sleep quality and exercise time of the day [75]. Sedliak., *et al.* recently assessed the effects of 1 hour hypertrophy-type of resistance training performed in the morning (7.30 am) and afternoon (4 pm) for 11 weeks on muscle hypertrophy, phosphorylation of selected muscle proteins and hormonal concentrations. The muscle strength and hypertrophy were not significantly different at any time point. Furthermore, testosterone levels were similar in morning and evening exercised groups and were comparable to that of controls [76]. Consistently, Zarrouk., *et al.* reported that the effect of the repeated pedaling sprint exercise on electromyographic activity of thigh muscles are independent of the time of the day that the exercises were conducted [77]. Rowland., *et al.* experimented on time of the day effects of exercises on functional markers of cardiac capacity [78]. After standard progressive cycle exercise test in the morning (8 am) and afternoon (4 pm) for 3 hours, no significant differences were observed in the cardiac variables (VO_2max, heart rate, cardiac output and systolic and diastolic myocardial functional markers) between morning and evening exercises [78]. Alley., *et al*. showed that after 30 minutes of resistance training carried out at 7 am, 1 pm and 7 pm that sleep stages and blood pressure at night are not affected by time of exercises [79]. Taleghani., *et al.* experimented on the effects of morning or evening walk regularly carried out by two elderly groups for 4 weeks. Morning or evening walks showed similar improvements on sleep quality [80]. Moreover, salivary melatonin levels have not shown significant differences in morning and evening exercises compared to controls after steady state running for 30 minutes and warm up for 5 minutes [81]. Similarly, growth hormone levels are not affected by the time of the exercise [53].

Discussion and Conclusion

It is clearly evident that RPE improve physiological and psychosocial health parameters [16-18]. The effects of the factors that affect the quality and outcome of RPE (viz. exercise intensity, duration, time of the day etc. and exact physiological mechanisms) need to be fully understood by physical trainers, sportsmen and scientists for effective training. Moreover, regular exercises have become a main driver of healthy life in the modern world. However, with day-today busy schedules, it has become a difficult task to find a time for RPE. Therefore, it is worthwhile to scientifically investigate the best time of the day for exercises to get the maximum benefit among busy schedules.

There are studies to support both views that exercises improve physiological, biochemical and psychological parameters of a person when the exercises are performed in the morning and/or evening [46-83]. Conclusions of the research discussed herein demonstrate that both morning and evening exercises increase aerobic and anaerobic power with favorable changes in the other physical parameters such as oxygen uptake and capacity, heart rate, blood flow, body weight, fat content and muscle strength, biochemical parameters such as blood glucose and hormone levels and psychological parameters such as stress, appetite and sleep behaviors [46-83]. However, it can be stated that the RPE preferentially affects certain parameters to be improved depending on the time of the day.

In finding reasons, many research groups suggest that time of day dependent hormonal changes may have effects on the differed outcomes of the time of exercise training. Additionally, individual variations in physiology can be a cause for variations observed in these differences which is hard to eliminate. Life style and underlying health conditions of individuals may also affect the outcome.

There are many limitations associated with this type of research, leaving grey areas and gaps that are needed to be filled. The quality of studies in this area of research is mostly questionable leaving number of challenges for future research. Lack of appropriate base line measurements, time, adequate follow ups, accuracy in certain data due to the subjective responses given by study participants and inconsistencies of the control groups are some of the challenges that this field of research faces. Furthermore, inability to acquire all appropriate data from same study participants is a major barrier to come up for complete and accurate conclusions.

Another factor that the investigators need to consider is the climate of the research setting, cultural variations and food habits that may have impact on the outcome of exercises. Therefore, when drawing generalized conclusions of effect of timing of exercises data from different continents may be useful. Hence, research on factors affecting exercise outcome should be thoroughly investigated in different communities.

Conflict of Interest

Authors declare there is no conflict of interest.

Bibliography

1. Lawrence D., *et al*. "The Epidemiology of Excess Mortality in People with Mental Illness". *The Canadian Journal of Psychiatry* 55.12 (2010): 752-760.
2. Murray CJL., *et al*. "Global Burden of Disease 2005: call for collaborators". *Lancet* 370.9582 (2007): 109-110.
3. Lopez AD., *et al*. "Global and regional burden of disease and risk factors 2001: systematic analysis of population health data". *Lancet* 367.9524 (2006): 1747-1757.
4. 5 Things You Should Know About Stress.
5. American Academy of Family Physicians Survey, 1988, U.S. News and World Report 11 (1995).
6. Stress symptoms: Effects on your body and behaviour.
7. Yusuf S., *et al*. "Global burden of cardiovascular diseases: part I: general considerations, the epidemiologic transition, risk factors, and impact of urbanization". *Circulation* 104.22 (2001): 2746-2753.
8. Sinha R., *et al*. "Stress as a common risk factor for obesity and addiction". *Biological Psychiatry* 373.9 (2013): 827-835.
9. Seery MD., *et al*. "Whatever does not kill us: cumulative lifetime adversity, vulnerability, and resilience". *Journal of Personality and Social Psychology* 99.6 (2010): 1025-1041.
10. Yaribeygi H., *et al*. "The impact of stress on body function: A review". *EXCLI Journal* 16 (2017): 1057-1072.
11. Yau YH., *et al*. "Stress and eating behaviors". *Minerva Endocrinol* 38.3 (2013): 255-267.
12. The Impact of Stress.
13. Kumar A., *et al*. "Stress: Neurobiology, consequences and management". *Journal of Pharmacy and Bioallied Sciences* 5.2 (2013): 91-97.
14. Chiesa A and Serretti A. "Mindfulness-based stress reduction for stress management in healthy people: a review and meta-analysis". *The Journal of Alternative and Complementary Medicine* 15.5 (2009): 593-600.
15. Bandara WMMS., *et al*. "The effect of long term physical exercises on plasma cortisol levels". *International Journal of Medicine* 5.2 (2017): 239-242.
16. Penedo FJ., *et al*. "Exercise and well-being: a review of mental and physical health benefits associated with physical activity". *Current Opinion in Psychiatry* 18.2 (2005): 189-193.
17. Stewart GM., *et al*. "Influence of exercise intensity and duration on functional and biochemical perturbations in the human heart". *The Journal of physiology* 594.11 (2016): 3031-3044.
18. Ruegsegger GN., *et al*. "Health Benefits of Exercise". *Cold Spring Harbor Perspectives in Medicine* 8.7 (2018): a029694.
19. Burton DA. "Physiological effects of exercise, Continuing Education in Anaesthesia" *Critical Care and Pain* 4.6 (2004): 185-188.

20. Oh DJ., *et al*. "The effects of strenuous exercises on resting heart rate, blood pressure, and maximal oxygen uptake". *Journal of Exercise Rehabilitation*12.1 (2016): 42-46.

21. Nystoriak MA and Bhatnagar A. "Cardiovascular Effects and Benefits of Exercise". *Frontiers in Cardiovascular Medicine* 5 (2018): 135.

22. Dinçer S., *et al*. "Effects of a regular exercise program on biochemical parameters of type 2 diabetes Mellitus patients". *The Journal of Sports Medicine and Physical Fitness* 56.11 (2015): 1384-1391.

23. Hackney AC. "Stress and the neuroendocrine system: the role of exercise as a stressor and modifier of stress". *Expert Review of Endocrinology and Metabolism* 1.6 (2006): 783-792.

24. Wittert G., *et al*. "Adaptation of the hypothalamopituitary adrenal axis to chronic exercise stress in humans". *Medicine and Science in Sports and Exercise* 28.8 (1996): 1015-1019.

25. Davies CT and Few JD. "Effects of exercise on adrenocortical function". *Journal of Applied Physiology* 35.6 (1973): 887-891.

26. Eliakim A. "Endocrine Response to Exercise and Training-Closing the Gaps". *Pediatric Exercise Science* 28.2 (2016): 226-232.

27. Eliakim Aand Nemet D. "The endocrine response to exercise and training in young athletes". *Pediatric Exercise Science* 25.4 (2013): 605-615.

28. Brown WJ., *et al.* "Prospective study of physical activity and depressive symptoms in middle-aged women". *American Journal of Preventive Medicine* 29.4 (2005): 265-272.

29. Paffenbarger RS Jr., *et al*. "Physical activity and personal characteristics associated with depression and suicide in American college men". *Acta Psychiatrica Scandinavica* 377 (1994): 16-22.

30. vanGool CH., *et al*. "Relationship between changes in depressive symptoms and unhealthy lifestyles in late middle aged and older persons: results from the Longitudinal Aging Study Amsterdam". *Age Ageing* 32.1 (2003): 81-87.

31. Belvederi MM., *et al*. "Physical Exercise in Major Depression: Reducing the Mortality Gap While Improving Clinical Outcomes". *Frontiers in Psychiatry* 9 (2019): 762.

32. Guure CB., *et al*. "Impact of Physical Activity on Cognitive Decline, Dementia, and Its Subtypes: Meta-Analysis of Prospective Studies". *BioMed Research International* (2017): 9016924.

33. How much should the average adult exercise every day?

34. Chomistek AK., *et al*. "Vigorous-intensity leisure-time physical activity and risk of major chronic disease in men". Medicine and Science in Sports and Exercise 44.10 (2012): 1898-1905.

35. Halbertsma JP and Göeken LN. "Stretching exercises: Effect on passive extensibility and stiffness in short hamstrings of healthy subjects" *Archives of Physical Medicine and Rehabilitatio* 75.9 (1994): 976-981.

36. Scalzi S., *et al*. "Nonlinear control techniques for the heart rate regulation in treadmill exercises". *IEEE Transactions on Biomedical Engineering* 59.3 (2012): 599-603.

37. Guo Jianjun., *et al*. "Effect of aerobic exercise training on cardiometabolic risk factors among professional athletes in the heaviest-weight class". *Diabetology and Metabolic Syndrome* 7 (2015): 78.

38. Myllymäki T., *et al*. "Effects of exercise intensity and duration on nocturnal heart rate variability and sleep quality". *European Journal of Applied Physiology* 112.3 (2012): 801-809.

39. Adamu B., *et al*. "Physical exercise and health: a review". *The Nigerian Journal of Medicine* 15.3 (2006): 190-196.

40. Gerber Mand Pühse U. "Review article: do exercise and fitness protect against stress-induced health complaints? A review of the literature". *Scandinavian Journal of Public Health* 37.8 (2009): 801-819.

41. Thomas RJ., *et al*. "Exercise-induced biochemical changes and their potential influence on cancer: a scientific review". *British Journal of Sports Medicine* 51.8 (2017): 640-644.

42. Seo DY., *et al*. "Morning and evening exercise". *Integrative Medicine Research* 2.4 (2013): 139-144.

43. Bandara WMMS and Rathnayake AJIS. "The Effect of Duration of Physical Exercises on Biochemical Parameters: A South Asian Perspective". *Chronicle of Medicine and Surgery* 2.5 (2018): 247-255.

44. Alizadeh Z., *et al*. "Comparison between the effect of 6 weeks of morning or evening aerobic exercise on appetite and anthropometric indices: a randomized controlled trial". *Clinical Obesity* 7.3 (2017): 157-165.

45. Chtourou H and Souissi N. "The effect of training at a specific time of day: a review". *Journal of Strength and Conditioning Research* 26.7 (2012): 1984-2005.

46. Hobson RM., *et al*. "Exercise capacity in the heat is greater in the morning than in the evening in man". *Medicine and Science in Sports and Exercise* 41.1 (2009): 174-180.

47. Brisswalter J., *et al*. "Morning-to-Evening Differences in Oxygen Uptake Kinetics in Short-Duration Cycling Exercise". *Chronobiology International* 24: 3 (2007): 495-506.

48. Fairbrother K., *et al*. "Effects of exercise timing on sleep architecture and nocturnal blood pressure in prehypertensives". *Vascular Health Risk Management* 10 (2014): 691-698.

49. Rief W., *et al*. "Overnight changes of immune parameters and catecholamines are associated with mood and stress". *Psychosomatic Medicine* 72.8 (2010): 755-762.

50. James GD., *et al*. "Differential circadian catecholamine and cortisol responses between healthy women with and without a parental history of hypertension". *American Journal of Human Biology* 26.6 (2014): 753-759.

51. Rahman M., *et al*. "Exercise Reduces Salivary Morning Cortisol Levels in Patients with Depression". *Molecular Neuropsychiatry* 4 (2018): 196-203.

52. Burley SD., *et al*. "The Differential Hormonal Milieu of Morning versus Evening May Have an Impact on Muscle Hypertrophic Potential". *PLoS ONE* 11.9 (2016): e0161500.

53. Kanaley JA., *et al*. "Cortisol and growth hormone responses to exercise at different times of day". *Journal of Clinical Endocrinology and Metabolism* 186.6 (2001): 2881-2889.

54. Kindermann W., *et al*. "Catecholamines, growth hormone, cortisol, insulin, and sex hormones in anaerobic and aerobic exercise". *European Journal of Applied Physiology* 49.3 (1982): 389-399.

55. Hill EE., *et al*. "Exercise and circulating cortisol levels: the intensity threshold effect". *Journal of Endocrinological Investigation* 31.7 (2008): 587-591.

56. Sedliak M., *et al*. "Effect of time-of-day-specific strength training on maximum strength and EMG activity of the leg extensors in men". *Journal of Sports Sciences* 26.10 (2008): 1005-1014.

57. Lericollais R., *et al*. "Time-of-day effects on fatigue during a sustained anaerobic test in well-trained cyclists". *Chronobiology International* 26.8 (2009): 1622-1635.

58. Maraki M., *et al*. "Acute effects of a single exercise class on appetite, energy intake and mood. Is there a time of day effect?". *Appetite* 45.3 (2005): 272-278.

59. Carandente F., *et al*. "Effects of endurance and strength acute exercise on night sleep quality". *International Sport Medicine Journal* 12: 3 (2011): 113-124.

60. Hill DW. "Effect of time of day on aerobic and anaerobic responses to high-intensity exercise". *Canadian journal of sport sciences* 17.4 (1992): 316-319.

61. Hill DW., *et al*. "Temporal specificity in adaptations to high-intensity exercise training". *Medical Science Sports Exercise* 30.3 (1998) 450-455.

62. Torii J., *et al*. "Effect of time of day on adaptive response to a 4-week aerobic exercise program". *Journal of Sports Medicine and Physical Fitness* 32.4 (1992): 348-352.

63. Rahmaninia F and B Mirzaei. "Comparison of maximal oxygen uptake (Vo2max) changes in selected young wrestlers in morning and afternoon". *Olympic* 9.1-2 (2001): 73-84.

64. Burgoon PW. "A comparison of morning and evening types during maximum exercise". *Journal of Applied Sport Science Research* 6.2 (2002): 115-119.

65. Havelková A., *et al*. "Circadian blood pressure variability and exercise therapy". *Scripta Medica* 80.5 (2007): 191-196.

66. Faisal A., *et al*. "O2 uptake and blood pressure regulation at the onset of exercise: interaction of circadian rhythm and priming exercise". *American Journal of Physiology-Heart and Circulatory Physiology* 299.6 (2010): H1832-H1842.

67. Hill DW., *et al*. "Morning-evening differences in response to exhaustive severe-intensity exercise". *Applied Physiology, Nutrition, and Metabolism* 39.2 (2014): 248-254.

68. Yamanaka Y., *et al*. "Morning and evening physical exercise differentially regulate the autonomic nervous system during nocturnal sleep in humans". *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology* 309.9 (2015): R1112-R1121.

69. Chtourou H., *et al*. "Diurnal variation in Wingate-test performance and associated electromyographic parameters". *Chronobiology International* 28.8 (2011): 706-713.

70. Nicolas A., *et al*. "Time of-day effects on myoelectric and mechanical properties of muscleduring maximal and prolonged isokinetic exercise". *Chronobiology International* 22.6 (2005): 997-1011.

71. Savikj M. "Afternoon exercise is more efficacious than morning exercise at improving blood glucose levels in individuals with type 2 diabetes: a randomised crossover trial". *Diabetologia* 62.2 (2019): 233-237.

72. Yoshida H. "Effects of the timing of exercise on the night sleep". *Psychiatry and Clinical Neurosciences* 52.2 (1998): 139-140.

73. Kim HK., *et al*. "Effects of Acute Endurance Exercise Performed in the Morning and Evening on Inflammatory Cytokine and Metabolic Hormone Responses". *PloS one* 10.9 (2015): e0137567.

74. Mohebbi H and Azizi M. "Maximal fat oxidation at the different exercise intensity in obese and normal weight men in the morning and evening". *Journal of Human Sport and Exercise* 6 (2011): 49-59.

75. Passos GS., *et al*. "Effects of moderate aerobic exercise training on chronic primary insomnia". *Sleep Medicine* 12.10 (2011): 1018-1027.

76. Sedliak M., *et al*. "Morphological, molecular and hormonal adaptations to early morning versus afternoon resistance training". *Chronobiology international* 35.4 (2018): 450-464.

77. Zarrouk N., *et al*. "Time of day effects on repeated sprint ability". *International Journal of Sports Medicine* 33.12 (2012): 975-980.

78. Rowland T., *et al*. "Time-of-day effect on cardiac responses to progressive exercise". *Chronobiology International* 28.7 (2011): 611-616.

79. Alley JR., *et al*. "Effects of resistance exercise timing on sleep architecture and nocturnal blood pressure". *The Journal of Strength and Conditioning Research* 29.5 (2015): 1378-1385.

80. Taleghani E., *et al*. "Comparison of the Effects of Morning and Evening Walks on Nighttime Sleep Quality Among Elderly People: A Randomized, Crossover, Clinical Trial". *Modern Care Journal* 13.4 (2016): e60210.

81. Carlson LA. "Influence of Exercise Time of Day on Salivary Melatonin Responses". *International Journal of Sports Physiology and Performance* 14.3 (2019): 351-353.

Volume 3 Issue 9 September 2019