MAKÜ
BURDUR MEHMET AKİF ERSOY ÜNİVERSİTESİ

OPEN ACCESS

Burdur Mehmet Akif Ersoy University Journal of Sport Sciences, 2024
Volume :2 Number: 2

The Effect of Chronotype on Athletic Performance: A Review Study

REVIEW STUDY

Yakup KÖSE[1 A-B-C-D], Raci KARAYİĞİT[2 A-E], Muhammed Uygar SERTKAYA[3 C-D], Mehmet Veysi BORA[4 E]

[1]Burdur Mehmet Akif Ersoy University, Sports Science Faculty, [2]Ankara University, Sports Science Faculty,[3]Ankara University, Institute of Health Sciences, [4] Mardin Artuklu University, Sports Science Faculty

Author Contribution Rate:
A) Study Design
B) Data Collection
C) Data Analysis
D) Article Writing
E) Critical Reading

Submission Date:
27 July 2024

Acceptance Date:
4 November 2024

Online Publication Date:
28 November 2024

ABSTRACT

In the age of professional sports, athletes, coaches, and technical staff pay more attention than ever to the science, medicine, and psychology behind athletic performance because even the slightest increase in performance is considered important. This study undertakes a compilation of research findings by employing literature review and content analysis techniques. Data included in the study has been obtained from qualified academic publications and studies identified through a literature review. These sources provide explanations on the subject and help resolve any uncertainties. In this regard, research published in the PubMed, Web of Science, and Google Scholar databases was searched using the keywords 'chronotype and performance', 'chronotype and cognitive performance', and 'chrono-exercise'. The findings were examined and compiled in alignment with the study's objectives. In the studies examined it is observed that athletes with a morning chronotype exhibit their best performance in the middle of the day, athletes with an intermediate chronotype show their peak performance in the afternoon, and athletes with an evening chronotype perform best in the evening. It is also observed that there is some evidence suggesting that the contribution of aerobic and anaerobic energy systems to the organism increases more in the evening than in the morning. This implies that chronotype may influence both the distribution and speed of energy systems. However, there is no study that directly tests this relationship. New and high-quality studies in this field will enable us to reach more definitive conclusions on the subject.

Key Words: Chronotype, Sports Performance, Aerobic, Anaerobic, Cognitive

Kronotipin Sportif Performansa Etkisi: Bir İnceleme Çalışması

ÖZET

Profesyonel spor çağında, sporcular, antrenörler ve teknik ekip, sportif performansın arkasındaki bilim, tıp ve psikolojiye eskiye nazaran daha fazla dikkat etmekte, çünkü performanstaki en ufak artış bile önemli kabul edilmekte. Araştırma, literatür taraması ve içerik analiz yöntemi kullanılarak yapılan derleme türü bir çalışmadır. Literatür taraması sonucu çalışmaya dahil edilen veriler; konuyu açıklayacak ve soru işaretlerini giderebilecek nitelikli akademik yayınlar ve çalışmalardan elde edilmiştir. Bu doğrultuda PubMed, Web of Science, Google Scholar veri tabanlarında ‘chronotype and performance’,'chronotype and cognitive performance’, 'chrono-exercise’ anahtar kelimeleri ile tarama yapılarak yayınlanan araştırmalar çalışmanın amacına uygun şekilde incelenmiş ve derlenmiştir. İncelenen çalışmalarda sabahcıl kronotipe sahip sporcuların kişisel olarak en iyi performansını gün ortasında, ara tip kronotipe sahip sporcuların en iyi performansını öğleden sonra ve akşamcıl tip kronotipe sahip sporcuların en yüksek performansı akşam gösterdiği görülmektedir. Ayrıca aerobik ve anaerobik enerji sistemlerinin organizmaya katkısının akşamları sabaha göre daha fazla arttığına dair bazı kanıtlar olduğunu gözlemlenmektedir bu da kronotip’in hem enerji sistemlerinin dağıtımını hem de hızını etkileyen bir faktör olabileceğini düşündürmektedir. Fakat bu ilişkiyi doğrudan test eden herhangi bir çalışma yoktur.Bu alanda yapılacak yeni ve kaliteli çalışmalar konu hakkında daha kesin sonuçlara ulaşmamızı sağlayacaktır.

Anahtar Kelimeler: Kronotip, Sportif Performans, Aerobik, Anaerobik, Bilişsel

ISSN: 3023-5359

Doi Number:
10.70701/makusbd.1523446

Introduction

Modern sports have come to recognize the importance of even the slightest improvements in performance. This has led to a heightened interest in athletic performance's scientific, medical, and psychological aspects (Currell & Jeukendrup, 2008). Understanding an athlete's individuality helps the athlete's performance. It can help you program your training to maximize your workout.

One factor that makes each unique is their innate circadian rhythm (Roenneberg et al., 2007). Circadian rhythm is a biological process in all living organisms and occurs daily. There is a bidirectional interaction between physiological and behavioral processes and circadian rhythm, including factors such as body temperature, hormones, cognition, and psychological mood (Filiz et al., 2021; Horne et al., 1976). Biological differences in circadian rhythm are expressed as chronotypes (Melo et al., 2017). Many genetic, environmental, and sociocultural factors affect chronotype (Toktaş et al., 2018). Chronotype is also affected by the photoperiod, as is the duration of light exposure at birth. Those exposed to short photoperiods at birth are morning lovers, while those exposed to long photoperiods are evening lovers (Montaruli et al., 2017).

Chronotype is the external indicator of circadian rhythm and consists of behavioral components such as preferred sleep and wake times (Kalmbach et al., 2017). In chronobiological studies, morning-type individuals are called "lark-hens," and evening-type individuals are called "owl-owls" (Gaina et al., 2006; Porto et al., 2007). Their sleep times are more flexible, and they are included in both groups. People who are not are defined as "Intermediate Type" (Saisema et al., 2014). Those who are morning types get up early and go to bed early. Depending on the state of maximum arousal, cognitive and physical performance are high in the morning, but a decrease in performance and fatigue is observed towards the evening (Cavallera et al., 2008; Hidalgo et al., 2002). Evening types are individuals who go to bed late, struggle to wake up in the morning, and exhibit enhanced cognitive and physical performance due to heightened arousal in the evening (McEnany & Lee, 2000).

Some studies investigating chronotypes in athletes show that athletes with a morningness preference are overrepresented. For example, 71% (n = 27) of Brazilian Paralympic athletes were classified as morning people (Silva et al., 2010). Similarly, 72%, 67%, and 59% of trained male triathletes (n = 49), runners (n = 119), and cyclists (n = 125), respectively, had morningness (Kunorozva et al., 2012). These results, which have been consistently replicated in studies with individual athletes, suggest that athletes have a higher incidence of morningness than reported in the general population (Henst et al., 2015; Rae et al., 2015; Lastella et al., 2010). Evidence shows that when athletes are free to choose, morning types prefer morning, and evening types prefer evening training (Kunorozva et al., 2012; Henst et al., 2015). Athletes report lower perceived exertion when training at their preferred times. Therefore, increasing training intensity at optimal times can accelerate adaptation (Kunorozva et al., 2014; Rae et al., 2015).

Studies have shown that anaerobic performance measurement tests performed on athletes with different chronotypes yield their lowest values in the morning and peak in the afternoon, varying based on the training time (Chtourou et al., 2012a; Chtourou et al., 2012b; Souissi et al., 2007; Souissi et al., 2002). In addition, studies show that resistance training and anaerobic performance peak in the evening for athletes compared to morning training performance (Grgic et al., 2019; Mirizio et al., 2020; Pallarés et al., 2014; Zarrouk et al., 2012). Evidence shows that when athletes are free to choose, the morning type prefers morning, and the evening prefers evening training (Kunorozva et al., 2012; Henst et al., 2015). Athletes report lower perceived exertion ratings during training at their preferred time. Considering the results, it can be predicted that increasing the intensity of training at the optimal time of day will accelerate training adaptation (Kunorozva et al., 2014; Rae et al., 2015).

Studies have shown that anaerobic performance measurement tests performed on athletes with different chronotypes have the lowest values in the morning hours and the highest values in the afternoon hours and vary depending on the training hours (Chtourou et al., 2012a; Chtourou et al., 2012b; Souissi et al., 2007; Souissi et al., 2002). In addition, studies have shown that resistance training and anaerobic exercise performance in athletes reach the highest level in the evening hours compared to morning training performance in terms of hours of the day (Grgic et al., 2019; Mirizio et al., 2020; Pallarés et al., 2014; Zarrouk et al., 2012).

Numerous studies have shown that professional and amateur athletes perform better during afternoon training. This performance increase is due to the synchronization between physiological, psychological and metabolic rhythms. These measurements peak in the early afternoon due to cardiovascular processes exhibiting circadian patterns (Bellastella et al., 2019; Kantermann et al., 2012). Core body temperature is thought to be 0.9 °C higher in the afternoon (Serin et al., 2019). As a result, muscles form more actin-myosin connections and use carbohydrates as energy substrates instead of lipids (Sabzevari Rad et al., 2021; Teo et al., 2011). In addition, exercise or training in the afternoon increases muscle growth and allows for optimal muscle movement, but the exact mechanism behind this effect is unclear (Aoyama & Shibata, 2020).

There is some evidence that the contributions of aerobic and anaerobic energy systems to the body are more significant in the evening than in the morning (Souissi et al., 2007; Hill DW, 1992). This evidence suggests that chronotype may be a potential factor affecting the distribution and speed of energy systems. However, no study has directly tested this relationship. In addition, many researchers have concluded that an athlete's peak performance during the day may change with changes in training duration and that this change will be determined by the athlete's chronotype (Brown et al., 2008; Winget et al., 1985).

Method

In this case, a study of the literature indicated a dearth of studies on the impact of chronotype on athletic performance. In light of this circumstance, the goal is to compile information in this area. : In this review study scientific articles and books discussing topics related to daytime and training performance as well as the impact of chronotype on sports performance were analysed. Researchers searched PubMed, Web of Science, Medline, Cochrane Library, Google Scholar, and ULAKBİM electronic databases using keywords such as "chronotype and sports performance," "daytime training performance," "effects of chronotype on cognitive performance," and "the importance of circadian rhythm for athletes." They reviewed the titles and abstracts of all relevant articles identified through the electronic search. Experimental studies, meta-analyses, systematic reviews, and the full text of relevant experimental studies were reviewed for the subject. In addition, an attempt was made to establish comprehensive integrity on the subject by examining books written in English and Turkish, as well as websites that are at the forefront of the subject

Aerobic Performance

The first study aimed to measure the effect of chronotype on soccer-specific motor skills in young soccer players (Roveda et al., 2020). In this study, morning types (n=25), evening types (n=25) and intermediate types (n=25) applied the 6-minute running test, IAT, and SJT at 09:00 and 18:00 in the morning. The study results showed that morning types performed better in the morning than in the evening, and evening types performed better in the evening than in the morning. No noticeable change was observed in the test results between morning and night for intermediate types. Morning types tended to score higher in morning tests than in the evening; the opposite was true for evening types. Another study evaluated the effects of morning-evening status on university rowing team performance (Brown et al., 2008). A total of 16 participants, eight males and eight females, were tested in a randomized and balanced design. Standard 2000 m ergometer rowing speed and long jump tests were performed in two sessions. The first session was conducted between 5:00 and 7:00 AM, and the second session was performed between 4:30 and 6:00 PM. Chronotypes of each athlete were determined as evening type (n = 8), morning type (n = 4), and intermediate type (n = 4). Rowing results show that evening-type and intermediate-type athletes did not differ in rowing performance between morning and evening, whereas morning-type athletes rowed significantly faster in the morning. Morning-type participants in the evening tests reported significantly slower rowing speeds than those in the morning tests. Morning types also showed a more pronounced decrease in performance later in the day compared to evening and intermediate types in both test measurements. No significant difference in rowing speed was observed between morning and evening measurements for types classified as evening and intermediate. Furthermore, these two groups did not show substantial differences in performance during the day.

Mulè et al. (2018) administered a test battery to 39 athletes to determine if there are performance variations in young football players based on their chronotype. These football players were classified as morning type (n=13), evening type (n=13), and intermediate type (n=13). Athletes performed the IAT and the 6-Minute Running Test at two different times: 9.00 am and 6.00 pm. The study results found statistically significant differences between the three chronotypes and the time of day. (Illinois Agility, $p < .01$; 6-Minute Run, $p < .01$). Evening types exhibited better performance in the evening than in the morning for both tests. Morning-type athletes performed morning better than evening. The results show that chronotype can affect aerobic performance in young football players.

In a different study, Fernandes et al. (2014) sought to ascertain how the time of day affected cycling time trial performance, pace, and energy systems. The study included nine recreational cyclists who exercised three days a week for four years. They were classified as intermediate type (n = 5) and morning type (n = 4) using Horne and Östberg's chronotype questionnaire. Participants performed a 1000 m cycling time trial in the morning and evening (at 8.00 am and 6.00 pm). As a result, for two chronotypes, the time to complete the time trial was shorter in the evening than in the morning (88.2±8.7 and 94.7±10.9 seconds, respectively,

$p < 0.05$), but there was no significant difference in tempo speed. As a result, it was stated that athletes with an intermediate type and morning chronotype improved their performance over morning hours during the evening hours.

Another study aimed to determine whether there was a relationship between chronotype and marathon performance in South African and Dutch marathon runners (Henst et al., 2015). South African (n = 95) and Dutch (n = 90) runners aged between 25 and 50 years were included in the study. Additionally, marathon runners (control group) who were training for the marathon and had participated in at least one marathon event per year were also included in the research. South African (n = 97) and Dutch (n = 98) active control groups consisted of men who exercised for at least one hour twice a week for the past three years. Three hundred eighty athletes were classified into one of the chronotype categories. The results showed that morning types runners had better current race times than evening types runners. South African runners had a much more morning-oriented chronotype than Dutch runners. South African and Dutch runners exhibited significantly more morning-type chronotypes than the control groups. Lastly, there were similarities in the mean chronotype scores between the Dutch and South African control groups.

In a different study, researchers collaborated with 216 individuals (114 women and 102 men) from 12 teams, comprising five field hockey teams and seven football teams from regional clubs at the international level. Performance data obtained from two performance tests (BLEEP tests, sprints, and skill/accuracy tests) conducted at six different times of the day, between 7.00 am and 10.00 pm (3-hour intervals), were analyzed separately for athletes with three different circadian phenotypes. As a result, it was found that teams with more players who had evening-type chronotypes were at a disadvantage in morning performance. Teams with more players with morning and intermediate chronotypes were disadvantaged in evening performances. In general, the performance levels of all teams were highest in the evening hours, while the peak performance times were in the afternoon. As a result, both performance levels and performance times were affected by chronotype (Facer-Childs & Brandstaetter, 2015a).

Another study evaluated the effect of chronotypes on athletes' physical performance using the BLEEP test with hockey players (Facer-Childs & Brandstaetter, 2015b). Twenty hockey players were classified as morning type (n = 5), intermediate type (n = 10), and evening type (n = 5) using the MEQ test. BLEEP testing was performed at six different times of the day: 7.00 am, 10.00 am, 1.00 pm, 4.00 pm, 7.00 pm and 10.00 pm. As a result, morning types exhibit their best personal performance in the first of the day, medium types show their peak performance in the afternoon, and evening types demonstrate their highest performance in the evening. Morning types offer their highest performance at 12:19 ± 1:43. Intermediate types performed the highest at 15.81±0.51 hours, while evening types reached 19.66±0.67 hours. However, the average time to peak performance for athletes with evening chronotypes was significantly later than those with intermediate and morning chronotypes. Based on the results, we can conclude that chronotype affects the time athletes take to reach peak performance and should be considered.

Table 1. Summary and results of the studies reviewed assessing the effect of chronotype on aerobic performance.

Study	N/Sample	Age (years) (mean ± SD)	Task	Test Time	Test protocol	Main Finding/Results
Roveda et al. 2020	75 M/ adolescent football player	14,19 ± 1,79	MEQ & PSQI	9.00 am & 6.00 pm	IAT & 6 min run	MT: Morning Point > Evening Point ET: Evening Point > Morning Point
Brown et al. 2008	8F-8M/ college rowers	19,6 ± 1,5	MEQ & BALM	5.00-7.00 am & 4.30-6.00 pm	2 km Rowing	MT significantly faster than other types
Mulè et al. 2018	39 M/ football player	(There is no data)	MEQ	9.00 am & 6.00 pm	IAT & 6 min run	ET is better in evening test MT is better in morning test
Fernandes et al. 2014	9 M/ bicyclist	31 ± 7,3	MEQ	8.00 am & 6.00 pm	1 km TT cycle	IT e and M Type as increased evening training performance
Henst et al. 2015	380 M/ runner	Age range 25-50	MEQ	6.30 am	Full & Half Marathon	M Type is better in the race
Facer -Childs & Brandstaetter 2015a	114 F-102 M/ team sports player	21,5 ± 3,96	RB-UB	7.00-10.00 am 1.00 – 4.00 pm 7.00 – 10.00 pm	BLEEP	The effect of chronotype on the BLEEP test was significantly observed
Facer-Childs & Brandstaetter 2015b	20 M/ athletes	Mean age 20,4	RB-UB	7.00 am 10.00 am 1.00 pm 4.00 pm 7.00 pm 10.00 pm	BLEEP	There are significant differences in performance among chronotypes

F: females; M: males;BAT: bassin anticipation time; MT: Morningness; ET: Eveningness; IT: Intermediate Type; MEQ: Morningness-Eveningness Questionnaire SLJ:standing long jump; PSQI:Pittsburgh Sleep Quality Index; BALM: basic language morningness; TT: time trial; RB-UB: Chronometric test

Anaerobic Performance

Nine of the articles included in the review examined the effect of chronotype on anaerobic performance. Brown et al (2008) conducted a study on collegiate rowers to measure the effect of chronotype on the extended jump test. Participants performed a practice test followed by three consecutive long jump tests in two sessions scheduled between 5:00 and 7:00 AM and 4:30 and 6:00 PM. The averages were then calculated. Three of the four-morning types jumped farther in the morning, while five of the eight evening types jumped farther in the evening. However, these results did not show a statistically significant difference in the effect of chronotype and time of day. Another study conducted by Roveda et al. (2020), aimed to measure the effect of chronotype on football-specific motor skills in young football players. In this study, 75 participants were categorized as Morning types (n = 25), Evening types (n = 25), and Intermediate types (n = 25). Sargent Jump Test was conducted to measure explosive power in two training performed the SJT at two different times of the day: 9.00 am and 6.00 pm. According to the study results, statistically significant differences were observed among the three chronotypes and the time of day (Sargent Jump, $p < .05$). In the Sargent jump test, individuals with evening chronotypes achieved higher performance results in the evening session compared to the morning session. In contrast, morning types performed better in the morning than in the evening. The results indicate that chronotype can impact anaerobic performance in young football players.Mulè et al. (2018) applied the Morning-Evening Questionnaire (MEQ) to 39 athletes to investigate possible performance differences based on chronotype differences among youth soccer players. They were classified as morning types (n=13), evening types (n=13), and middle types (n=13). Athletes performed SJT at two different times, 09:00 AM and 06:00 PM. According to the study results, statistically significant differences occurred between the three chronotypes and the time of the day (Sargent Jump, $p<.05$). Evening types showed higher performance in the evening than in the morning session. In contrast, morning types performed better in the morning than in the evening session. The results indicate that chronotype can affect anaerobic performance in adolescent soccer players.

Another study (Fernandes et al., 2014) aimed to determine the effect of time of day on performance during a 1000 m bicycle time trial. In this context, nine recreational cyclists who had been training more than 3 times a week for the last 4 years, intermediate type (n= 5) and morning type (n= 4), participated in the study. In the incremental test results performed on a bicycle ergometer at 08:00 in the morning and 18:00, it was stated that a medium effect size for average anaerobic power and higher values were observed in the evening. This increased average anaerobic power in the evening was accompanied by a medium effect size for average power output and a large effect size according to time in favor of the evening. In summary, it was concluded that anaerobic performance might increase in the evening in athletes with intermediate and morning-type chronotypes.

Martín-López et al. (2022) aimed to determine whether the time of day affects women's volleyball performance and to investigate the relationship between chronotype and volleyball-specific performance.

Fifteen young female athletes (9 intermediate types, 5 evening types, and 1-morning type) found statistical differences favoring the evening in standing long jump, straight leg raise test (dominant leg), and dynamic balance (non-dominant leg) tests. No statistical difference was found in vertical jump tests and isometric handgrip strength. While there were statistically significant differences in the dominant limb's straight leg raise test results between the evening and morning sessions, no such difference was observed in the non-dominant limb. When evening and morning sessions were compared, no statistically significant difference was found between chronotypes in the vertical jump and single-leg jump tests in volleyball. Although there was no relationship between all these results and chronotype, evening training may maximize physical performance in female volleyball players.

Anderson et al. (2018) aimed to reveal the effect of circadian rhythm on performance in university swimming team athletes. In this context, 27 participants, 19 female and 8 male, were categorized as morning type (n = 3), evening type (n = 7), and medium type (n = 17). They participated in the 200 m freestyle race in two sessions (07:00 and 19:00). The results reported that evening athletes swam an average of 6.3% slower than morning athletes in the morning time trial. In addition, evening types showed a more significant morning handicap compared to morning types and swam slower in the morning.

Another study compared swimmers' 200m swimming time-trial performance at 06:30 and 18:30 while considering their chronotype (Rae et al., 2015). Twenty-six swimmers participated in the study. Swimmers were classified as Morning (n=15) and Intermediate (n=11). As for the results, there was a significant difference: morning types swam faster in the 6.30 am session, while intermediate types swam faster in the 6.30 pm session. No difference between morning and evening performances was found when swimmers were evaluated as a single group. However, grouping swimmers by chronotype and their typical training time of day revealed a significant difference in performance.

López-Samanes et al. (2016) conducted a study to investigate the effect of circadian rhythm on tennis performance. They evaluated the vertical jump and 10 m sprint performance of 13 male tennis players, one morning, three evening, and nine medium types. Measurements were taken at 9:00 am and 4:30 pm. When morning and afternoon post-tests were compared, vertical jump height was significantly higher in the evening session compared to the morning session (4.5 ± 5.1%). The 10-meter sprint performance time was considerably shorter in the afternoon compared to the morning (2.7 ± 3.0%). This result indicates that tennis performance in the evening hours may be significantly better than in the morning hours and that morning athletes may have a handicap.

In another paper (Fessi & Souissi 2019), 20 male athletes, Intermediate Type (n = 11) and Morning Type (n = 9), were included in the study to investigate the effect of time of day on anaerobic performance. Participants performed RAST (Running Anaerobic Sprint Test) at 7:30 AM and 5:30 PM. According to the study results, RAST performance was significantly higher in the evening compared to the morning in both measurements: peak power, average power and minimum power.

Table 2. Summary and results of the studies reviewed assessing the effect of chronotype on anaerobic performance.

Study	N/Sample	Age (years) (mean ± SD)	Task	Test Time	Test protocol	Main Finding/Results
Roveda et al. 2020	75 M/ adolescent football player	14,19 ± 1,79	MEQ & PSQI	9.00 am & 6.00 pm	SJT	M Type: Morning Point > Evening Point E Type: Evening Point > Morning Point
Brown et al. 2008	8F-8M/ college rowers	19,6 ± 1,5	MEQ & BALM	5.00-7.00 am & 4.30-6.00 pm	SLJ	The effect of chronotype has been statistically observed on rowing speed and long jump performance
Mulè et al. 2018	39 M/ football player	(There is no data)	MEQ	9.00 am & 6.00 pm	SJT	The effect of chronotype on the SJT was significantly observed
Fernandes et al. 2014	9 M/ bicyclist	31 ± 7,3	MEQ	8.00 am & 6.00 pm	200m TT	Athletes with IT and MT chronotypes show improvements in the evenings
Martín-López et al. 2022	15 F/ volleyball player	22,3 ± 7,2	MEQ	9.00 am & 7.00 pm	VJ, SJV,	There is no statistical difference
Anderson et al. 2018	19 F- 8 M/ college swimmers	Age range 18-22	MEQ	7.00 am & 7.00 pm	200 m freestyle swimming TT	There is no statistical difference
Rae et al. 2015	8 F-18 M/ team sports player	21,5 ± 3,96	MEQ	6.30 am 6.30 pm	200 m swimming TT	There are significant differences in performance among chronotypes
López-Samanes et al. 2016	13 M/ tennis player	22,5 ± 3,7	MEQ	9.00 am & 4.30 pm	10 m run, VJ	There are significant differences in performance among chronotypes
Fessi & Souissi 2019	20 M/ athletes	25,85 ± 2,03	MEQ	7.30 am & 5.30 pm	RAST	PP, AP and MP were higher in the evening

F:females; M:males; SJT: sargent jump test; M Type: Morningness; E Type: Eveningness; SLJ:standing long jump; MEQ: Morningness-Eveningness Questionnaire; PSQI: Pittsburgh Sleep Quality Index; BALM: basic language morningnss; TT: time trial; VJ:vertical jump; RAST: running based anaerobic sprint test; PP: peak power; AP: average power; MP: min power

Cognitive Performance

Three of the articles included in the review examine the effect of chronotype on cognitive performance. In the first study (Ceylan and Günay, 2020), morning-type (N=23) and evening-type (N=23) team athletes were included to investigate the impact of time of day and chronotype on anticipating timing performance. The athletes' prediction time performances at high stimulus speed (12 mph) were measured with the Bassin Prediction Timer at two different times of the day (8.00 am-10.00 am, 8.00 pm -10.00 pm), at least two days apart, at 5 sessions. As a result, the absolute error score of the morning subject group was significantly lower in the morning than in the evening. There was a statistically significant difference in favor of the evening hours when the total error scores of the evening group were compared between the morning and evening hours. It is clear from the data that an athlete's chronotype may significantly impact how well they perform cognitively.

In another study (Facer-Childs et al., 2018), 56 healthy volunteers categorized as morning (n = 25) and evening (n = 31) chronotypes were included in the study to investigate the effect of chronotype on cognitive performance. Cognitive performance measurements were measured at different times (08.00, 14.00, 20.00). Psychomotor alertness tests and executive function tests were used as cognitive performance assessments. According to the research results, morning types performed 8.4% better in the early morning hours than evening types. A significant interaction was found between time of day and chronotype for executive function (EF) performance. Measurements of morning types showed a 5.9% improvement in measurements at 08.00, which was 5.9% better than evening types. A significant interaction was also found between time of day and chronotype for psychomotor alertness test performance. In conclusion, a significant difference in cognitive performance measures was found between participants with morning and evening chronotypes according to the time of day.

Matchock and Toby Mordkoff (2009) collaborated with 80 participants, with evening type (n = 44) and morning type/intermediate type (n = 36), who participated in this study. Participants were administered the Attention Network Test (ANT) and a self-report alertness measure at 8.00 am, 12.00 pm, 4.00 pm, and 8.00 pm. As a result, participants with morning type and intermediate type chronotypes tended to perform better in the early hours of the day. In contrast, participants with evening chronotypes performed better later in the day. Participants with an intermediate type chronotype received higher scores at 12.00 pm and 4.00 pm. In addition, the measure of alertness revealed an interaction between the time of day and chronotype. Scores increased in the early hours for all participants but then decreased towards the evening, only in participants with a morningness/intermediate chronotype.

Table 3. Summary and results of the studies reviewed assessing the effect of chronotype on cognitvie performance.

Study	N/Sample	Age (years) (mean ± SD)	Task	Test Time	Test protocol	Main Finding/Results
Facer-Childs et al. 2018	33 F- 23 M/ college rowers	19,6 ± 1,5	MCTQ	2.00 pm 8.00 pm & 8.00 am	PVT & MAT	ET were significantly impaired in all measures in the morning compared to MT
Matchock & Toby Mordkoff 2009	57 F- 23 M/ football player	Mean age 21,6 age range 18-28	MEQ	8.00 am 12.00 pm 4.00 pm 8.00 pm	ANT	MT and IT better in the morning ET better in the evening
Ceylan & Günay 2020	46 M/ team sports players	20,52 ± 1,87	MEQ	8.00 – 10.00 am & 8.00 - 10.00 pm	BAT	MT better in the morning ET better in the evening

F:females; M:males; SJT: sargent jump test; M Type: Morningness; E Type: Eveningness; SLJ:standing long jump; MEQ: Morningness-Eveningness Questionnaire; PSQI: Pittsburgh Sleep Quality Index; BALM: basic language morningnss; TT: time trial; VJ:vertical jump; RAST: running based anaerobic sprint test; PP: peak power; AP: average power; MP: min power

BURDUR MEHMET AKİF ERSOY ÜNİVERSİTESİ

OPEN ACCESS

Burdur Mehmet Akif Ersoy University Journal of Sport Sciences, 2024
Volume: 2 Number: 2

Discussion and Conclusion

Chronotype, an individual's preference for morning or evening, can significantly impact athletic performance (Vitale, 2017; Roden, 2017; Roveda, 2020; Ayala, 2021). Athletes with a morning chronotype generally perform better in the morning, while those with an evening chronotype have been reported to perform better in the evening (Roveda, 2020). This may be due to several factors, including its impact on physiological and psychological characteristics that affect performance, such as body temperature and perception of effort.

In addition to being a morning or evening person, the time of day can significantly affect athletic performance. In some sports disciplines, morning people perform better in the morning, while evening people perform better in the evening. For example, Mule et al. (2018) reported that among young football players, morning people perform better in the morning, while evening people perform better in the evening. Unlike football, performance has been improved in sports such as volleyball and tennis in the evening. However, while different results have been obtained regarding the day in other sports, some studies have concluded that chronotype does not significantly affect physical performance criteria (Anderson et al., 2018; Lopez et al., 2022). However, contrary to these results, some studies have reported that evening swimmers have a decrease in morning performance compared to evening performance (Rae et al., 2015). Similarly, differences were observed in performance measurements taken at different times in some tests. These contradictory results indicate that individual differences and athletes' training routines may also play an important role. An athlete can achieve optimum performance by adjusting their training hours and sleep patterns according to their chronotype. In addition, it may be beneficial for athletes to align their training hours and sleep patterns harmoniously to increase their sports performance. In conclusion, although it is difficult to determine the effect of training duration and chronotype on sports performance, it is seen that in some sports disciplines, morning types perform better in the morning hours. In contrast, evening types perform better in the evening hours. Of course, it should not be forgotten that the results may be advantageous for morning types in branches where the competition hours are in the morning. The results may benefit evening types in branches where the competition hours are in the evening.

It is also possible that chronotype may affect cognitive performance. Accordingly, the optimal performance hours of athletes or individuals may vary. It should be remembered that cognitive alertness is coordinated with each individual's circadian rhythm. However, since each athlete is unique, adjusting training hours and sleep patterns according to personal preferences and biorhythms is essential for the best performance. In this regard, aligning the training regimen with the goals and objectives of both coaches and athletes and adjusting their training loads accordingly can be critical in achieving success in individual and team sports.

This review includes the results of research conducted in various sports branches on the impact of chronotype on sports performance. However, since these studies' sample sizes and methodologies vary, the generalization of the results may be limited. More research is needed to understand chronotype's impact on sports performance fully.

References

Anderson, A., Murray, G., Herlihy, M., Weiss, C., King, J., Hutchinson, E., Ingram, K. K. (2018). Circadian effects on performance and effort in collegiate swimmers. *Journal of Circadian Rhythms*, 16.

Aoyama, S., & Shibata, S. (2020). Time-of-day-dependent physiological responses to meal and exercise. *Frontiers in Nutrition*, 7, 18.

Atkinson, G., Todd, C., Reilly, T., Waterhouse, J. (2005). Diurnal variation in cycling performance: influence of warm-up. *Journal of Sports Sciences*, 23(3), 321-329.

Ayala, V., Martínez-Bebia, M., Latorre, J. A., Gimenez-Blasi, N., Jimenez-Casquet, M. J., Conde-Pipo, J., Mariscal-Arcas, M. (2021). Influence of circadian rhythms on sports performance. *Chronobiology International*, 38(11), 1522-1536.

Bellastella, G., De Bellis, A., Maiorino, M. I., Paglionico, V. A., Esposito, K., Bellastella, A. (2019). Endocrine rhythms and sport: it is time to take time into account. *Journal of Endocrinological Investigation*, 42, 1137-1147.

Brown, F. M., Neft, E. E., LaJambe, C. M. (2008). Collegiate rowing crew performance varies by morningness-eveningness. *The Journal of Strength & Conditioning Research*, 22(6), 1894-1900.

Cavallera, G. M., Giudici, S. (2008). Morningness and eveningness personality: A survey in literature from 1995 up till 2006. *Personality and Individual Differences*, 44(1), 3-21.

Ceylan, H. İ., Günay, A. R. (2020). The Effects of Time of day and chronotype on anticipation timing performance in team sports athletes.

Chtourou, H., Souissi, N. (2012a). The effect of training at a specific time of day: a review. The *Journal of Strength & Conditioning Research*, 26(7), 1984-2005.

Chtourou, H., Driss, T., Souissi, S., Gam, A., Chaouachi, A., Souissi, N. (2012b). The effect of strength training at the same time of the day on the diurnal fluctuations of muscular anaerobic performances. *The Journal of Strength & Conditioning Research*, 26(1), 217-225.

Currell, K., Jeukendrup, A. E. (2008). Validity, reliability and sensitivity of measures of sporting performance. *Sports Medicine*, 38, 297-316.

Dergaa, I., Fessi, M. S., Chaabane, M., Souissi, N., Hammouda, O. (2019). The effects of lunar cycle on the diurnal variations of short-term maximal performance, mood state, and perceived exertion. *Chronobiology International*, 36(9), 1249-1257.

Facer-Childs, E. R., Boiling, S., Balanos, G. M. (2018). The effects of time of day and chronotype on cognitive and physical performance in healthy volunteers. *Sports Medicine-open*, 4(1), 1-12.

Facer-Childs, E., Brandstaetter, R. (2015a). Circadian phenotype composition is a major predictor of diurnal physical performance in teams. *Frontiers in Neurology*, 6, 208.

Facer-Childs, E., Brandstaetter, R. (2015b). The impact of circadian phenotype and time since awakening on diurnal performance in athletes. *Current Biology*, 25(4), 518-522.

Fernandes, A. L., Lopes-Silva, J. P., Bertuzzi, R., Casarini, D. E., Arita, D. Y., Bishop, D. J., Lima-Silva, A. E. (2014). Effect of time of day on performance, hormonal and metabolic response during a 1000-M cycling time trial. *PloS one*, 9(10), e109954.

Filiz, A., Karasu, G., Vakıf, B., Dilek Şahbaz, C., Filiz, Z., Doğu, E., Takmaz, T., Çalı, H., Tanoğlu, B. (2021). Chronotype and sleep quality assessment of patients with polycystic ovary syndrome.

Gaina, A., Sekine, M., Kanayama, H., Takashi, Y., Hu, L., Sengoku, K., Kagamimori, S. (2006). Morning-evening preference: Sleep pattern spectrum and lifestyle habits among Japanese junior high school pupils. *Chronobiology International*, 23(3), 607-621.

Grgic, J., Lazinica, B., Garofolini, A., Schoenfeld, B. J., Saner, N. J., Mikulic, P. (2019). The effects of time of day-specific resistance training on adaptations in skeletal muscle hypertrophy and muscle strength: A systematic review and meta-analysis. *Chronobiology International*, 36(4), 449-460.

Henst, R. H., Jaspers, R. T., Roden, L. C., Rae, D. E. (2015). A chronotype comparison of South African and Dutch marathon runners: The role of scheduled race start times and effects on performance. *Chronobiology International*, 32(6), 858-868.

Hidalgo, M. P., Camozzato, A., Cardoso, L., Preussler, C., Nunes, C. E., Tavares, R., Chaves, M. L. F. (2002). Evaluation of behavioral states among morning and evening active healthy individuals. *Brazilian Journal of Medical and Biological Research*, 35, 837-842.

Hill, D. W., Borden, D. O., Darnaby, K. M., Hendricks, D. N., Hill, C. M. (1992). Effect of time of day on aerobic and anaerobic responses to high-intensity exercise. *Canadian Journal of Sport Sciences= Journal Canadien Des Sciences du Sport*, 17(4), 316-319.

Horne, J. A., Ostberg, O. (1976). A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. *International Journal of Chronobiology*, 4(2), 97-110.

Kalmbach, D. A., Schneider, L. D., Cheung, J., Bertrand, S. J., Kariharan, T., Pack, A. I., Gehrman, P. R. (2017). Genetic basis of chronotype in humans: insights from three landmark GWAS. *Sleep*, 40(2).

Kantermann, T., Forstner, S., Halle, M., Schlangen, L., Roenneberg, T., Schmidt-Trucksäss, A. (2012). The stimulating effect of bright light on physical performance depends on internal time. *PLoS One*, 7(7).

Kunorozva, L., Roden, L. C., Rae, D. E. (2014). Perception of effort in morning-type cyclists is lower when exercising in the morning. *Journal of Sports Sciences*, 32(10), 917-925.

Kunorozva, L., Stephenson, K. J., Rae, D. E., Roden, L. C. (2012). Chronotype and PERIOD3 variable number tandem repeat polymorphism in individual sports athletes. *Chronobiology International*, 29(8), 1004-1010.

Lastella, M., Roach, G. D., Hurem, D. C., Sargent,

C. (2010). Does chronotype affect elite athletes' capacity to cope with the training demands of elite triathlon. Living in a, 24(7), 25-28.

López-Samanes, Á., Moreno-Pérez, D., Maté-Muñoz, J. L., Domínguez, R., Pallarés, J. G., Mora-Rodriguez, R., Ortega, J. F. (2017). Circadian rhythm effect on physical tennis performance in trained male players. *Journal of Sports Sciences*, 35(21), 2121-2128.

Martín-López, J., Sedliak, M., Valadés, D., Muñoz, A., Buffet-García, J., García-Oviedo, R., López-Samanes, Á. (2022). Impact of time-of-day and chronotype on neuromuscular performance in semi-professional female volleyball players. *Chronobiology International*, 39(7), 1006-1014.

Matchock, R. L., Toby Mordkoff, J. (2009). Chronotype and time-of-day influences on the alerting, orienting, and executive components of attention. *Experimental Brain Research*, 192, 189-198.

McEnany, G., Lee, K. A. (2000). Owls, larks and the significance of morningness/eveningness rhythm propensity in psychiatric-mental health nursing. *Issues in Mental Health Nursing*, 21(2), 203-216.

Melo, M. C., Abreu, R. L., Neto, V. B. L., de Bruin, P. F., de Bruin, V. M. (2017). Chronotype and circadian rhythm in bipolar disorder: a systematic review. *Sleep Medicine Reviews*, 34, 46-58.

Mirizio, G. G., Nunes, R. S. M., Vargas, D. A., Foster, C., Vieira, E. (2020). Time-of-day effects on short-duration maximal exercise performance. *Scientific Reports*, 10(1), 9485.

Montaruli, A., Galasso, L., Caumo, A., Cè, E., Pesenti, C., Roveda, E., Esposito, F. (2017). The circadian typology: the role of physical activity and melatonin. *Sport Sciences for Health*, 13, 469-476.

Mulè, A., Castelli, L., Galasso, L., Bruno, E., Roveda, E., Caumo, A., Montaruli, A. (2018). Circadian Tipology and physical performance in adolescent soccer players. *Italian Journal of Anatomy & Embryology/Archivio Italiano di Anatomia Ed Embriologia*, 123.

Pallarés, J. G., López-Samanes, Á., Moreno, J., Fernández-Elías, V. E., Ortega, J. F., Mora-Rodríguez, R. (2014). Circadian rhythm effects on neuromuscular and sprint swimming performance. *Biological Rhythm Research*, 45(1), 51-60.

Porto, R., Duarte, L., Menna-Barreto, L. (2006). Circadian variation of mood: comparison between different chronotypes. *Biological Rhythm Research*, 37(5), 425-431.

Rae, D. E., Stephenson, K. J., Roden, L. C. (2015). Factors to consider when assessing diurnal variation in sports performance: the influence of chronotype and habitual training time-of-day. *European Journal of Applied Physiology*, 115(6), 1339–1349.

Roden, L. C., Rudner, T. D., Rae, D. E. (2017). Impact of chronotype on athletic performance: current perspectives. *ChronoPhysiology and Therapy*, 1-6.

Roenneberg, T., Kuehnle, T., Juda, M., Kantermann, T., Allebrandt, K., Gordijn, M., Merrow, M. (2007). Epidemiology of the human circadian clock. *Sleep Medicine Reviews*, 11(6), 429-438.

Roveda, E., Mulè, A., Galasso, L., Castelli, L., Scurati, R., Michielon, G., Montaruli, A. (2020). Effect of chronotype on motor skills specific to soccer in adolescent players. *Chronobiology International*, 37(4), 552-563.

Sabzevari Rad, R., Mahmoodzadeh Hosseini, H., Shirvani, H. (2021). Circadian rhythm effect on military physical fitness and field training: a narrative review. *Sport Sciences for Health*, 17, 43-56.

Saisema, J., Johns, J., Chokchisiriwatt, D., Areeyawongsatit, T., Johns, N. P. The Relatıonshıp Of Chronotype And Sleep Qualıty Of Unıversıty Students.

Serin, Y., Acar Tek, N. (2019). Effect of circadian rhythm on metabolic processes and the regulation of energy balance. *Annals of Nutrition and Metabolism*, 74(4), 322-330.

Silva, A., Queiroz, S. S., Winckler, C., Vital, R., Sousa, R. A., Fagundes, V., de Mello, M. T. (2012). Sleep quality evaluation, chronotype, sleepiness and anxiety of Paralympic Brazilian athletes: Beijing 2008 Paralympic Games. British *Journal of Sports Medicine*, 46(2), 150-154.

Souissi, N., Bessot, N., Chamari, K., Gauthier, A., Sesboüé, B., Davenne, D. (2007). Effect of time of day on aerobic contribution to the 30-s Wingate test performance. *Chronobiology International*, 24(4), 739-748.

Souissi, N., Gauthier, A., Sesboüé, B., Larue, J., Davenne, D. (2002). Effects of regular training at the same time of day on diurnal fluctuations in muscular performance. *Journal of Sports Sciences*, 20(11), 929-937.

Teo, W., Newton, M. J., McGuigan, M. R. (2011). Circadian rhythms in exercise performance: implications for hormonal and muscular adaptation. *Journal of Sports Science & Medicine*, 10(4), 600.

Toktaş, N., Eskiocak, H. (2018). Egzersiz yapan ve yapmayan kadınlarda kronotipe göre depresyon düzeyinin belirlenmesi. *Spor Eğitim Dergisi*, 2(3), 11-25.

Vitale, J.A., Weydahl, A. (2017). Chronotype, physical activity, and sport performance: a systematic review. *Sports Medicine*, 47, 1859-1868.

Winget, C.M., DeRoshia, C.W., Holley, D.C. (1985). Circadian rhythms and athletic performance. *Medicine and Science in Sports and Exercise*, 17(5), 498-516.

Zarrouk, N., Chtourou, H., Rebai, H., Hammouda, O., Souissi, N., Dogui, M., Hug, F. (2012). Time of day effects on repeated sprint ability. *International Journal of Sports Medicine*, 33(12), 975–980.

Burdur Mehmet Akif Ersoy University Journal of Sport Sciences, 2024
Volume: 2 Number: 2

Corresponding Author Information

Author Name Surname: *Yakup KOSE*
Organisation: *Burdur Mehmet Akif Ersoy University*
Address: *Istiklal Campus Stadium, Burdur-Antalya Highway 10th km A-3 Entrance, 15200 Yakaköy/Burdur Center/Burdur*
Orcid Number: *https://orcid.org/0009-0009-1552-6818*