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# Do Different Times of The Day Affect Dart Throwing Performance?

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## Abstract

**Background:** Dart sport has become a sport that has recently become widespread among sports branches and its popularity is increasing rapidly day by day. With this popularization, research on darts is increasing. It is stated that athletes can do the training they do at any time of the day with a much better performance at a different time, as in many changing conditions. In addition, at a different time of day, fatigue may be reached later or recovery may occur more quickly. For these reasons, knowing the effect of training at different times of the day is important for both the coach and the athlete.
**Objectives:** The aim of this study was to investigate the effect of different times of the day on throwing performance in darts, an indoor skill in which focus, attention, concentration are at the forefront and environmental factors are less effective than outdoor skill.
**Methods:** In this study, 16 dart athletes (8 boys, 8 girls) with a sport age of 2 - 3 years and an age of 12 - 14 years, who did not have any health problems in Mardin province, participated voluntarily: 2 m and 2.37 m from two different distances at 8.00 and 17.00, 1 day apart. Before the dart throws, the Daily Rhythm Determination Scale for Children was administered to the participants. The center of the dartboard was placed at eye level for each subject. After the throws, the Perceived Difficulty Scale was applied. In the analysis examining the relationship between perceived degree of difficulty, morningness-eveningness and throwing, the subjects' evening throwing scores and evening perceived degree of difficulty scores were examined; a negative and significant relationship was observed in the eveningist group ($r = -1$, $P = 0.01$). No significant relationship was observed in the morning group.
**Results:** In the study, a statistically significant difference was found between the subjects' morning and evening throws at 2 m and 2.37 cm. In both morning and evening groups, it was determined that the throwing performance increased in the evening measurements.
**Conclusions:** As a result, this study concluded that there is an effect of time of day in dart sport and that dart throws made in the evening give better results than dart throws made in the morning. Based on these results, it is recommended that a program should be made by the coaches considering the school programs and daily routines to reduce the effect of time of day. It is thought that this study will be important for chronobiological researches to reveal the factors affecting performance as well as the effect of time of day in darts sport.

*Keywords:* Darts, Perceived Difficulty, Biological Rhythm

## 1. Background

Dart sport is a sport branch that has recently become popular among sports branches and its popularity is increasing rapidly day by day. In dart sport, it is aimed to score points by throwing and hitting small arrows on the aiming board consisting of numbered rings (1). Due to the structure of darts sport, many factors such as concentration, attention, balance, and coordination can be beneficial for performance. Especially, attention and concentration can be impacted by external factors. The time period is one of these factors. It is stated that hand-eye coordination, which is one of the important factors especially for darts sport, may differ according to the time of day (2, 3).

Biological rhythm is defined as the cyclical, biochemical, physiological and behavioral responses of many living things to recurring physical factors in the external world (4). Circadian rhythms, one of the subgroups of biological rhythms, are rhythmic changes in the sleep-wake cycle that lasts about a day (5). Circadian rhythm is a personal characteristic that shows some

physiological and psychological relationships and is thought to affect various aspects of an individual's life. Circadian rhythm or morning-evening refers to individuals' preferences for morning or evening activities (6). Each 24-hour cycle varies on an individual level. These differences are manifested by characteristic features often called "morning type," "evening type" and "intermediate type" (7). These classifications are basically used to reveal various aspects of differences between individuals. Morning-type people prefer early rising and morning activities and are more energetic and awake in the morning. Evening type people, on the other hand, prefer to wake up later and sleep later and prefer afternoon or evening activities. In addition, the intermediate type is also included in the classification. The question of how the human body will react to exercises performed at different times of the day has been a subject of curiosity by researchers. In studies conducted on athletes, it is stated that athletes can perform the training they do at any time of the day with a much better performance at a different time, as in many changing conditions. In addition, at a different time of the day, the level of fatigue may be reached later or recovery may occur more quickly. For example, it is stated that exercise performance is higher in strength training performed in the afternoon and evening hours compared to the morning hours. This difference is explained as the effect of factors affecting circadian rhythm, neuromuscular regulation, hormones, nutrition, body temperature and even the molecular clock of skeletal muscle (8). However, it is also known that moderate-intensity aerobic exercises performed in the morning provide a superior performance increase compared to evening hours (9). For these reasons, knowing the effect of training in different time zones is important for athletes, especially for coaches (10). When the studies are examined, it is stated that circadian rhythm influences athletes' performances, training and competitions (11-13). In addition, circadian rhythm preference has been found to be associated with academic achievement, emotional and behavioral problems, personality, social problems, attention, sleep duration and sleep quality (14-16). Many sport-related variables have been shown to have circadian rhythms. Edwards et al. (17) used dart throwing as a model to investigate the factors affecting motor performance and stated that the effects of time of day on performance depend on the relative importance of strength and accuracy (17). When the studies conducted in childhood are examined, it is seen that the morning type is more common in childhood, but it is stated that the transition to evening occurs during adolescence in both boys and girls due to genetic and/or environmental factors (18). It has also been emphasized that the intermediate type may also be prevalent during this period and that factors such as melatonin and heat may affect this. In a study conducted on children it was found that the best performance for ball skills occurred at 15:40. As a result of the study, it was revealed that the existence and development of daily performance profiles leads to the idea that the mental load of the task depends on the mental load of the task and the greater the load, the more difficult the perceived task is (19). In addition, some studies have revealed that being a morning person and an evening person may also create a difference in thinking style. They found that morning people think more analytically, while evening people process information more holistically (20, 21). In their study on anaerobic performance, Hill and Chtourou (22) found that individuals identified as both morning and evening types reached higher mean and peak power values per body weight produced in the evening compared to the morning. In addition, it is said that some physiological characteristics such as heart rate and respiratory frequency are also affected by circadian rhythm during dart competitions and that different times of the day are effective on this (23). Considering that many internal and external factors are effective on performance, determining how the athlete feels internally is also among the effective factors. Perceived difficulty is a valid and easily accessible method in this sense (24). Moreover, numerous theories of motor performance have identified perceived difficulty as an important variable in the regulation of emotions and motivation. Tracking athletes allows to determine how the athlete feels physiologically-psychologically during training, competitions, and fitness (25, 26).

In this context, the aim of this study was to investigate the effect of different times of the day on throwing performance in darts.

## 2. Objectives

The aim of this study was to investigate the effect of different times of the day on throwing performance in darts, an indoor skill where focus, attention and concentration are at the forefront and environmental factors are less effective than outdoor skills.

## 3. Methods

### 3.1. Working Protocol

The dart throwing measurements of the subjects were performed at the Bağlıca Secondary School Gymnasium in Artuklu district of Mardin province at 8.00 and 17.00 h: 2 m

and 2.37 m (27-30) from two different distances at 8.00 and 17.00 h). The center of the dartboard was placed at eye level for each subject. After each throw at two distances, the throw distances were recorded and the dart was collected for the next throw. They came to the hall 20 min before the throws, were given warm-up throws and allowed to drink water and rest. After their throws, the Perceived Difficulty Scale was applied. Approval was obtained from Gazi University Ethics Commission (Code No: 2023-778) before the measurements and the measurements were performed in accordance with the Declaration of Helsinki.

### 3.2. Experimental Group

In this study, 16 darts athletes (8 boys, 8 girls) with 2 - 3 years of sporting age and 12 - 14 years of age who did not have any health problems in Mardin Province participated voluntarily (Table 1). There are 40 licensed dart athletes in Mardin province. Since the students live in rural areas, 16 athletes studying at the same school were included in the research due to transportation problems. The subjects and their families were informed before the study and parental consent form was signed.

### 3.3. Height and Body Weight Measurements

Body weights were measured barefoot with a Premier Pws scale with a precision of 0.1 kg and recorded in kg. Height was measured using a Mesilife Pt-810a stadiometer. Height was recorded in centimeters.

### 3.4. Score Calculations

The target used for scoring in dart throwing performance consisted of a dartboard with a series of 10 concentric darts. All athletes threw with the same darts so as not to affect the dart throws. Each dart throw was scored according to its position on the board (0 to 10). A dart throw that missed the target or ricocheted during the dart throws was given a score of 0. For the evaluation of dart throwing performance, the athletes threw 2 times at the target. The first throw was made at 8.00 am and the second throw was made at 17.00 pm (27, 28, 30). Participants throwing darts two different distances in randomized order. The first was 2 m (31) and the second was 2.37 m (29). The target used in scoring dart throwing performance consists of a series of 10 concentric dartboards. In order not to affect the dart throws, all athletes throwing with the same dart arrows. Each dart throw is scored (0 to 10) according to its position on the board. A dart throw that missed the target or bounced was given 0 points. To evaluate the dart throwing performance, the athletes throw at the target twice. The first throw was made at 8.00 in the morning and the second throw was at 17.00 in the evening (27, 28). Participants throwing from two different distances in random order. They made 6 throw (32), the first from a normal distance of 2 m (31) and the second from a normal distance of 2.37 m (29).

### 3.5. Perceived Difficulty Rating

Borg's modified (33) CR10 Perceived Difficulty Rating (PDR) Scale was used to determine the participants' Perceived Difficulty Rating. The scoring of this scale ranges from 1 to 10, with a score of 1 indicating the lowest degree of difficulty and a score of 10 indicating the highest degree of difficulty. With the Modified Perceived Difficulty Scale, the difficulty level of the throw was determined with a score after each dart throw. The question "How was the training?" is asked by the athlete to describe the PDR of the average training intensity during training or throwing, and athletes are asked to give a nominal score between 0 - 10.

### 3.6. Daily Rhythm Identification Scale for Children

This scale was developed by Carskadon et al. (34) and has been accepted and widely used by researchers. The scale was adapted into Turkish by Beşoluk and Önder (35). The scale used in the study was used to measure which of the morningness or eveningness type characteristics the participants had based on their self-assessment. The questions assess individuals' self-reported preferred time for sleeping and waking, physical and mental activities in a 24-hour period. The scale is multiple choice and consists of 10 questions. The scale was administered to dart athletes the day before their dart performance was taken. Validity and reliability were confirmed. When scoring the scale, a = 1, b = 2, c = 3, d = 4, e = 5 points were used to calculate the total score. Items marked with * were reversed when calculating the scoring.

### 3.7. Data Analysis

Since the data did not show normal distribution, non-parametric tests were preferred in the analysis of the data. In addition to descriptive statistics, Mann Whitney U test was used to determine whether there was a significant difference between the morning and evening throws of the students. Simple linear correlation analysis was used to examine the relationship between students' morning and evening throws and the relationship between students' throw scores and perceived difficulty scores. Statistical analysis of the data collected in the study was performed using SPSS 26.0 package program. Statistical results were evaluated at 95% confidence interval and $P < 0.05$ significance level.

**Table 1.** Descriptive Statistics of Athletes Participating in the Research

| | N | Mean ± SD |
|---|---|---|
| **Girls** | | |
| Age | 8 | 12.8750 ± 0.99103 |
| BW | 8 | 45.7500 ± 7.70436 |
| Height | 8 | 155.0000 ± 6.04743 |
| Sport age | 8 | 2.3750 ± 0.51755 |
| BMI | 8 | 18.8875 ± 2.73832 |
| **Boys** | | |
| Age | 8 | 12.6250 ± 0.91613 |
| BW | 8 | 42.8750 ± 4.82368 |
| Height | 8 | 155.2500 ± 7.90569 |
| Sport age | 8 | 2.6250 ± 0.51755 |
| BMI | 8 | 17.7500 ± 0.88479 |

Abbreviations: BMI, body mass index; and BW, body weight.

## 4. Results

Looking at Table 2, the perceived difficulty level of the athletes was evaluated 32 times, both in the morning and in the evening. PLD of dart throws made from a distance of 2 m in the morning is $X^{-} = 3.50$, and PLD of dart throws made from a distance of 2 m in the evening is $X^{-} = 3.06$. Dart throws thrown from a distance of 2.37 m in the morning were found to be PLD $X^{-} = 4.88$, and darts thrown from a distance of 2.37 m in the evening were found to be PLD $X^{-} = 4.37$. When evaluated in general, morning PLD is $X^{-} = 4.1875$, evening PLD is $X^{-} = 3.7188$.

According to the results of the Mann Whitney U test, which was conducted to reveal whether there was a significant difference between the morning and evening throwing of the students, a significant difference was found between the students' 2 m morning and evening throwing ($P = 0.032$) and between the 2.37 m morning and evening throwing ($P = 0.029$) (Table 3).

According to the simple linear correlation analysis conducted to examine the relationship between morning and evening throws among students, a significant correlation was not found in the morning group. In contrast, a positive and significant correlation was identified in the evening group ($r = 1$, $P = 0.01$) (Table 4).

When the relationship between students' morning throwing scores and morning perceived difficulty scores was analyzed, it was observed that there was a negative and significant relationship in the morning group ($r = -0.80$, $P = 0.028$), while there was a negative and significant relationship in the evening group ($r = -1$, $P = 0.01$). When the students' evening throwing scores and evening perceived difficulty scores were analyzed, it was observed that there was a negative and significant relationship in the evening group ($r = -1$, $P = 0.01$), while there was no significant relationship in the morning group (Table 5).

## 5. Discussion

As a result of this study, which was conducted to examine the effect of different times of the day on throwing performance in darts sport, a statistically significant difference was found between the subjects' morning and evening throws from 2 m and 2.37 cm. In both morning and evening groups, it was determined that the throwing performance increased in the evening measurements.

When the literature is examined, there are studies showing that the time of day is effective on strength, flexibility and simple reaction. In these studies, it is stated that especially circadian rhythm is effective on sensory, motor, psychomotor, perceptual and cognitive functions (2, 36-38). In addition, studies have emphasized that short-term maximum performance is usually best in the afternoon towards evening (36, 37). It is stated that target accuracy, focus and attention, which affect performance in closed skills such as darts, are affected by circadian rhythm (39). In addition, fluctuations in exercise performance depending on the time of day are supported by studies in many sports branches (37, 40-42). In a review study, it was stated that performance increased in the evening hours when body temperature was at its peak in the majority of the publications reviewed (43). Mirizio et al. (44) and colleagues reported that short-term

**Table 2.** Statistics on Perceived Difficulty Levels in the Morning and Evening

| | N | Mean ± SD |
|---|---|---|
| **PLD 2m morning** | 16 | 3.50 ± 0.894 |
| **PLD 2m evening** | 16 | 3.06 ± 0.854 |
| **PLD 2,37m morning** | 16 | 4.88 ± 1.088 |
| **PLD 2,37m evening** | 16 | 4.37 ± 1.204 |
| **Morning difficulty** | 32 | 4.1875 ± 1.20315 |
| **Evening difficulty** | 32 | 3.7188 ± 1.22433 |

Abbreviation: PLD, perceived difficulty level.

**Table 3.** Morning and Evening Dart Performance Statistics of Athletes

| | Mean ± SD | |
|---|---|---|
| | **2 m Dart Throw** | **2.37 m Dart Throw** |
| **Morning 8.00** | 39.06 ± 3.29 | 37.88 ± 3.61 |
| **Evening 17.00** | 41.88 ± 3.40 | 40.94 ± 3.23 |
| **P** | 0.032 | 0.029 |

**Table 4.** Morning and Evening: Pearson Correlation Test

| Variables | Mean ± SD |
|---|---|
| **Morning** | |
| 8.00 | 39.14 ± 2.47 |
| 17.00 | 41.71 ± 2.13 |
| r | 0.44 |
| P | 0.31 |
| **Evening** | |
| 7.00 | 39 ± 5.65 |
| 17.00 | 42.5 ± 6.36 |
| r | 1 |
| P | 0.01 |

**Table 5.** Pearson Correlation Test Between Perceived Difficulty Level, Morningness-Eveningness and Attitudes

| | Morning PLD | Evening PLD |
|---|---|---|
| **Morningness** | | |
| r | -0.80 | -0.37 |
| P | 0.028 | 0.41 |
| **Eveningness** | | |
| r | -1 | -1 |
| P | 0.01 | 0.01 |

exercise performances fluctuated consistently throughout the day and peaked between 16.00 and 20.00 hours with amplitudes ranging from 1.7 to 17.5%. In two other studies, Jarraya et al. (2, 38), in their study on handball goalkeepers, stated that different times of the day have an effect on perceptual, cognitive and psychomotor functions, while performance usually peaks near the evening hours. Souissi et al. (45) examined the effects of time of day on short-term exercise performance in 10 - 11-year-old boys and found that performance increased significantly from morning to afternoon (with an amplitude ranging from 3.5 to 6%), but there was no significant difference between 14:00 and 18:00. Chtourou et al. (27) investigated the effect of time of day on short-term maximum performances before and after a judo match in young judo players and found that muscle strength and power of judo players were significantly higher in the afternoon than in the morning. In this context, when morning and evening performances in different branches are compared, it can be said that athletes generally show maximum performance in the afternoon hours. Souissi et al. (46) reported that circadian rhythm has a significant effect on short-term performances in cycling, jumping and strength tests in children aged 9 - 11 years.

Darts is an individual sport and the effects of internal and external factors on individuals may be different. Especially in school-age children, the fact that they go to school in two different time periods, morning and noon, reveals the importance of being a morning and evening person and circadian rhythm (47). While morning people prefer to be active in the early hours of the day, evening people prefer to be active later in the day (48). In the study, it is thought that the morning group could perform better if they could be trained in the morning.

However, since the subjects were at school in the morning, they could not train. The degree of perceived difficulty in the evening group was found to be lower than the morning group. Both groups (morning and evening) showed better throwing performance in the evening and the evening group perceived it more positively. When both distances at which the subjects throw were evaluated, it was determined that the subjects had more difficulty in morning throwing than in evening throwing. In this case, it was determined that the subjects were able to get more efficient results in the evening than in the morning.

Delignières et al. (25) stated that the perceived difficulty of the task is a very important variable in the regulation of emotions and motivation in studies on motor performance. In addition, a study showing that sleep is also important was conducted by Axelsson et al. (49), who reported that sleep deprivation affects performance and directly affects motor and cognitive performance. Edwards and Waterhouse (29) reported that for a simple task such as throwing darts at a target, awake time and sleep loss affect dart performance and increased sleep duration, decreased alertness, and increased fatigue in athletes are associated with negative effects on sports performance. Edwards et al. (17), reported that time of day has an effect on the factors affecting motor performance using dart throwing performance. Edwards et al. (17), stated that one of the main findings of their study on the effects of time of day and distance on dart throwing accuracy consistency was that the dart throwing task was performed better and performance improved as the day progressed. In addition to these studies, Bonnefond et al. (19) show that circadian rhythm affects performance only when the level of difficulty is high. In this case, research shows that the duration, difficulty, cognitive domain, application methods and measured variables of a study can affect the time when the performance is best completed.

Finally, in the analysis examining the relationship between perceived degree of difficulty, morningism-eveningism and throwing, the subjects' evening throwing scores and evening perceived degree of difficulty scores were examined; a negative and significant relationship was observed in the eveningist group ($r = -1$, $P = 0.01$). There was no significant relationship in the morning group. Elghoul et al. (26) conducted a study on 12 healthy boys to examine the effects of time of day on dart throwing performance and perception of task difficulty in boys aged 9-10 years and found that dart throwing performance was significantly better in the afternoon than in the morning. Delignières et al. (25) stated that goal difficulty has a positive effect on performance in many studies in target sports in line with the results of the study. In conclusion, factors such as time of day, subjective target difficulty, time spent awake and distance can affect performance.

Moreover, these circadian rhythms can be influenced by various factors, such as regular training at a certain time of the day, i.e. regular training in the morning may increase morning performance and regular training in the afternoon may increase evening performance to the normal daily peak or higher. Adherence to training is reported to be higher during regular training hours compared to other hours (50).

### 5.1. Conclusions

Based on the results of this study, it is recommended that a program should be made by the coaches considering the school programs and daily routines in order to reduce the effect of the time of day on the performance of the athletes. It is important for coaches to know at which time of the day their athletes are at their peak performance, especially in sports that require high attention such as darts. It is thought that this study will be important for chronobiological research to reveal the factors affecting performance as well as the effect of time of day in darts sport.

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## Footnotes

**Authors' Contribution:** Study concept and design: Orhan Ö. and Kadı MN. Analysis and interpretation of data: Yüksel Y. and Orhan Ö. Drafting of the manuscript: Orhan Ö. and Kadı MN. Statistical analysis: Yüksel Y. and Orhan Ö. Critical revision of the manuscript for important intellectual content: Kadı MN and Orhan Ö.

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## References


1. Şahin HM. *Dictionary of physical education and sports*. Morpa Cultural Publications; 2006.
2. Jarraya S, Jarraya M, Chtourou H, Souissi N. Diurnal variations on cognitive performances in handball goalkeepers. *Biol Rhythm Res*. 2013;**45**(1):93–101. https://doi.org/10.1080/09291016.2013.811032.
3. Kurt C. Chronobiology and physical performance. *Turkiye Klinikleri J Sports Sci*. 2010;**2**(2):103–8.
4. Haus E. Chronobiology in the endocrine system. *Adv Drug Deliv Rev*. 2007;**59**(9-10):985–1014. [PubMed ID: 17804113]. https://doi.org/10.1016/j.addr.2007.01.001.
5. Laposky AD, Bass J, Kohsaka A, Turek FW. Sleep and circadian rhythms: Key components in the regulation of energy metabolism. *FEBS Lett*. 2008;**582**(1):142–51. [PubMed ID: 17707819]. https://doi.org/10.1016/j.febslet.2007.06.079.
6. Preckel F, Lipnevich AA, Schneider S, Roberts RD. Chronotype, cognitive abilities, and academic achievement: A meta-analytic investigation. *Learn Individ Differ*. 2011;**21**(5):483–92. https://doi.org/10.1016/j.lindif.2011.07.003.
7. Melo MC, Garcia RF, Araujo CF, Luz JH, Bruin PF, Bruin VM. Chronotype in bipolar disorder: An 18-month prospective study. *Braz J Psychiatry*. 2020;**42**(1):68–71. [PubMed ID: 31269097]. [PubMed Central ID: PMC6986486]. https://doi.org/10.1590/1516-4446-2019-0489.
8. Gabriel BM, Zierath JR. Circadian rhythms and exercise - re-setting the clock in metabolic disease. *Nat Rev Endocrinol*. 2019;**15**(4):197–206. [PubMed ID: 30655625]. https://doi.org/10.1038/s41574-018-0150-x.
9. LeGates TA, Fernandez DC, Hattar S. Light as a central modulator of circadian rhythms, sleep and affect. *Nat Rev Neurosci*. 2014;**15**(7):443–54. [PubMed ID: 24917305]. [PubMed Central ID: PMC4254760]. https://doi.org/10.1038/nrn3743.
10. Chtourou H, Hammouda O, Souissi H, Chamari K, Chaouachi A, Souissi N. The effect of ramadan fasting on physical performances, mood state and perceived exertion in young footballers. *Asian J Sports Med*. 2011;**2**(3):177–85. [PubMed ID: 22375237]. [PubMed Central ID: PMC3289213]. https://doi.org/10.5812/asjsm.34757.
11. Gauthier A, Davenne D, Martin A, Van Hoecke J. Time of day effects on isometric and isokinetic torque developed during elbow flexion in humans. *Eur J Appl Physiol*. 2001;**84**(3):249–52. [PubMed ID: 11320645]. https://doi.org/10.1007/s004210170014.
12. Guette M, Gondin J, Martin A. Time-of-day effect on the torque and neuromuscular properties of dominant and non-dominant quadriceps femoris. *Chronobiol Int*. 2005;**22**(3):541–58. [PubMed ID: 16076653]. https://doi.org/10.1081/CBI-200062407.
13. Waterhouse J, Drust B, Weinert D, Edwards B, Gregson W, Atkinson G, et al. The circadian rhythm of core temperature: origin and some implications for exercise performance. *Chronobiol Int*. 2005;**22**(2):207–25. [PubMed ID: 16021839]. https://doi.org/10.1081/cbi-200053477.
14. Beşoluk Ş. Morningness-eveningness preferences and university entrance examination scores of high school students. *Pers Individ Differ*. 2011;**50**(2):248–52. https://doi.org/10.1016/j.paid.2010.09.038.
15. Beşoluk Ş, Önder I. Do seasonal changes and teaching time affect academic performance of pre-service teachers? *Biol Rhythm Res*. 2011;**42**(5):445–56. https://doi.org/10.1080/09291016.2010.528634.
16. Besoluk S, Onder I, Deveci I. Morningness-eveningness preferences and academic achievement of university students. *Chronobiol Int*. 2011;**28**(2):118–25. [PubMed ID: 21231873]. https://doi.org/10.3109/07420528.2010.540729.
17. Edwards B, Waterhouse J, Atkinson G, Reilly T. Effects of time of day and distance upon accuracy and consistency of throwing darts. *J Sports Sci*. 2007;**25**(13):1531–8. [PubMed ID: 17852679]. https://doi.org/10.1080/02640410701244975.
18. Roenneberg T, Kuehnle T, Pramstaller PP, Ricken J, Havel M, Guth A, et al. A marker for the end of adolescence. *Curr Biol*. 2004;**14**(24):R1038–9. [PubMed ID: 15620633]. https://doi.org/10.1016/j.cub.2004.11.039.
19. Bonnefond A, Rohmer O, Hoeft A, Muzet A, Tassi P. Interaction of age with time of day and mental load in different cognitive tasks. *Percept Mot Skills*. 2003;**96**(3 Pt 2):1223–36. [PubMed ID: 12929776]. https://doi.org/10.2466/pms.2003.96.3c.1223.
20. Diaz-Morales JF, Escribano C. Circadian preference and thinking styles: implications for school achievement. *Chronobiol Int*. 2013;**30**(10):1231–9. [PubMed ID: 24024592]. https://doi.org/10.3109/07420528.2013.813854.
21. Fabbri M, Mencarelli C, Adan A, Natale V. Time-of-day and circadian typology on memory retrieval. *Biol Rhythm Res*. 2013;**44**(1):125–42. https://doi.org/10.1080/09291016.2012.656244.
22. Hill DW, Chtourou H. The effect of time of day and chronotype on the relationships between mood state and performance in a Wingate test. *Chronobiol Int*. 2020;**37**(11):1599–610. [PubMed ID: 32924652]. https://doi.org/10.1080/07420528.2020.1786394.
23. Valdez P, García A; Ramírez. Circadian rhythms in cognitive performance: implications for neuropsychological assessment. *ChronoPhysiology Ther*. 2012. https://doi.org/10.2147/cpt.S32586.
24. Aoki MS, Arruda AF, Freitas CG, Miloski B, Marcelino PR, Drago G, et al. Monitoring training loads, mood states, and jump performance over two periodized training mesocycles in elite young volleyball players. *Int J Sports Sci Coa*. 2016;**12**(1):130–7. https://doi.org/10.1177/1747954116684394.
25. Delignieres D, Famose JP, Thépaut-Mathieu C, Fleurance P. A psychophysical study of difficulty rating in rock climbing. *Int J Sport Psychol*. 1993;**24**:404–16.
26. Elghoul Y, Frikha M, Abdelmlak S, Chtourou H, Dammak K, Chamari K, et al. Time-of-day effect on dart-throwing performance and the perception of the difficulty of the task in 9–10 year-old boys. *Biol Rhythm Res*. 2014;**45**(4):523–32. https://doi.org/10.1080/09291016.2013.869439.
27. Chtourou H, Aloui A, Hammouda O, Chaouachi A, Chamari K, Souissi N. The effect of time-of-day and judo match on short-term maximal performances in judokas. *Biol Rhythm Res*. 2013;**44**(5):797–806. https://doi.org/10.1080/09291016.2012.756269.
28. Chtourou H, Chaouachi A, Driss T, Dogui M, Behm DG, Chamari K, et al. The effect of training at the same time of day and tapering period on the diurnal variation of short exercise performances. *J Strength Cond Res*. 2012;**26**(3):697–708. [PubMed ID: 21857363]. https://doi.org/10.1519/JSC.0b013e3182281c87.
29. Edwards BJ, Waterhouse J. Effects of one night of partial sleep deprivation upon diurnal rhythms of accuracy and consistency in throwing darts. *Chronobiol Int*. 2009;**26**(4):756–68. [PubMed ID: 19444754]. https://doi.org/10.1080/07420520902929037.
30. Elghoul Y, Frikha M, Masmoudi L, Chtourou H, Chaouachi A, Chamari K, et al. Diurnal variation of cognitive performance and perceived difficulty in dart-throwing performance in 9–10-year-old boys. *Biol Rhythm Res*. 2014:1–13. https://doi.org/10.1080/09291016.2014.921409.
31. Emanuel M, Jarus T, Bart O. Effect of focus of attention and age on motor acquisition, retention, and transfer: a randomized trial. *Phys Ther*. 2008;**88**(2):251–60. [PubMed ID: 18042657]. https://doi.org/10.2522/ptj.20060174.
32. Koyuncu M. Broadbent's cognitive approach and its effect on motor performance in sports. *Psychology*. 2011;**2**(5):472–6. https://doi.org/10.4236/psych.2011.25073.
33. Borg GA. Psychophysical bases of perceived exertion. *Med Sci Sports Exerc*. 1982;**14**(5):377–81. [PubMed ID: 7154893].
34. Carskadon MA, Vieira C, Acebo C. Association between puberty and delayed phase preference. *Sleep*. 1993;**16**(3):258–62. [PubMed ID: 8506460]. https://doi.org/10.1093/sleep/16.3.258.
35. Önder İ, Beşoluk Ş. Adaptation of the morningness eveningness scale for children into Turkish. *Biol Rhythm Res*. 2013;**44**(2):313–23. https://doi.org/10.1080/09291016.2012.681848.
36. Abedelmalek S, Chtourou H, Souissi N, Tabka Z. Effect of time-of-day and racial variation on short-term maximal performance. *Biol Rhythm*

*Res*. 2013;**44**(5):787–96. https://doi.org/10.1080/09291016.2012.756261.
37. Chtourou H, Driss T, Souissi S, Gam A, Chaouachi A, Souissi N. The effect of strength training at the same time of the day on the diurnal fluctuations of muscular anaerobic performances. *J Strength Cond Res*. 2012;**26**(1):217–25. [PubMed ID: 21993020]. https://doi.org/10.1519/JSC.0b013e31821d5e8d.
38. Jarraya S, Jarraya M, Chtourou H, Souissi N. Effect of time of day and partial sleep deprivation on the reaction time and the attentional capacities of the handball goalkeeper. *Biol Rhythm Res*. 2013;**45**(2):183–91. https://doi.org/10.1080/09291016.2013.787685.
39. Çavdar EK M. Zihinsel canlandırmanın sirkadiyen ritme göre dart atış performansına etkisi. *Beden Eğitimi ve Spor Bilimleri Dergisi*. 2021;**15**(1):49–59.
40. Facer-Childs E, Brandstaetter R. The impact of circadian phenotype and time since awakening on diurnal performance in athletes. *Curr Biol*. 2015;**25**(4):518–22. [PubMed ID: 25639241]. https://doi.org/10.1016/j.cub.2014.12.036.
41. Hammouda O, Chtourou H, Chahed H, Ferchichi S, Chaouachi A, Kallel C, et al. High intensity exercise affects diurnal variation of some biological markers in trained subjects. *Int J Sports Med*. 2012;**33**(11):886–91. [PubMed ID: 22791622]. https://doi.org/10.1055/s-0032-1301887.
42. Lericollais R, Gauthier A, Bessot N, Sesboue B, Davenne D. Time-of-day effects on fatigue during a sustained anaerobic test in well-trained cyclists. *Chronobiol Int*. 2009;**26**(8):1622–35. [PubMed ID: 20030545]. https://doi.org/10.3109/07420520903534492.
43. Thun E, Bjorvatn B, Flo E, Harris A, Pallesen S. Sleep, circadian rhythms, and athletic performance. *Sleep Med Rev*. 2015;**23**:1–9. [PubMed ID: 25645125]. https://doi.org/10.1016/j.smrv.2014.11.003.
44. Mirizio GG, Nunes RSM, Vargas DA, Foster C, Vieira E. Time-of-day effects on short-duration maximal exercise performance. *Sci Rep*. 2020;**10**(1):9485. [PubMed ID: 32528038]. [PubMed Central ID: PMC7289891]. https://doi.org/10.1038/s41598-020-66342-w.
45. Souissi H, Chaouachi A, Chamari K, Dogui M, Amri M, Souissi N. Time-of-day effects on short-term exercise performances in 10- to 11-year-old boys. *Pediatr Exerc Sci*. 2010;**22**(4):613–23. [PubMed ID: 21242609]. https://doi.org/10.1123/pes.22.4.613.
46. Souissi H, Chtourou H, Chaouachi A, Dogui M, Chamari K, Souissi N, et al. The effect of training at a specific time-of-day on the diurnal variations of short-term exercise performances in 10- to 11-year-old boys. *Pediatr Exerc Sci*. 2012;**24**(1):84–99. [PubMed ID: 22433267]. https://doi.org/10.1123/pes.24.1.84.
47. Randler C, Diaz-Morales JF, Rahafar A, Vollmer C. Morningness-eveningness and amplitude - development and validation of an improved composite scale to measure circadian preference and stability (MESSi). *Chronobiol Int*. 2016;**33**(7):832–48. [PubMed ID: 27123963]. https://doi.org/10.3109/07420528.2016.1171233.
48. Demirhan E, Onder I, Horzum MB, Masal E, Besoluk S. Adaptation of the morningness-eveningness stability scale improved (MESSi) into Turkish. *Chronobiol Int*. 2019;**36**(3):427–38. [PubMed ID: 30614279]. https://doi.org/10.1080/07420528.2018.1560307.
49. Axelsson J, Kecklund G, Akerstedt T, Donofrio P, Lekander M, Ingre M. Sleepiness and performance in response to repeated sleep restriction and subsequent recovery during semi-laboratory conditions. *Chronobiol Int*. 2008;**25**(2):297–308. [PubMed ID: 18533328]. https://doi.org/10.1080/07420520802107031.
50. Chtourou H, Souissi N. The effect of training at a specific time of day: A review. *J Strength Cond Res*. 2012;**26**(7):1984–2005. [PubMed ID: 22531613]. https://doi.org/10.1519/JSC.0b013e31825770a7.