ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

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Diurnal Variations in Well-Trained Semi-Professional Soccer Players' Performance in the Running-Based Anaerobic Sprint Test

İyi Antrenmanlı Yarı-profesyonel Futbolcuların Koşuya Dayalı Anaerobik Sprint Test Performansında Diurnal Varyasyonlar

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This manuscript was part of Zeliha Nur Kalyon's postgraduate thesis titled "An evaluation of diurnal variations in soccer players' anaerobic performance using the running-based anaerobic sprint test" at Trakya University, Institute of Health Science, Master of Physical Education and Sport.

ABSTRACT Objective: This study examined whether there were diurnal variations in the running-based anaerobic sprint test (RAST) performance of semi-professional, male soccer players. **Material and Methods:** Participants included 25 people whose ages ranged from 18-36 years old, (mean=20 years); weight ranged from 52-110 kg (mean=72 kg); mean height was 176.92±6.17 cm; experience playing soccer ranged from 5-22 years (mean=8 years); and average weekly training duration was 3-22 h (mean=6 h). Chronotypes were estimated using the Turkish version of the Horn-Östberg Morningness-Eveningness Personality Questionnaire. They performed RAST in a randomized study design using the Newtest Powertimer 300-series photocells twice, on two separate days, one week apart, either in the morning (8.30-10.00 AM) or afternoon (5.00-6.00 PM). Before each of test session; the air temperature and humidity; along with their oral body temperature and 24 h food intake data were recorded. **Results**: Paired t-tests were used to analyze differences due to the time of day in the RAST variables. Maximum power (p>0.05), minimum power (p>0.05), mean power (p>0.05), fatigue index (p>0.05), air temperature (p>0.05), body temperature, and caloric intake (p>0.05) did not differ in the morning and afternoon. **Conclusion:** In contrast to previous research, RAST performance showed no diurnal variations. A possible explanation could be attributed to the participants' chronotypes conforming to neither the morning nor evening types. However, replicating this study with soccer players having an extreme morning or extreme evening chronotypes may lead to different results.

Keywords: Chronotype; diurnal rhythms; running-based anaerobic sprint test; soccer; morningness-eveningness

ÖZET Amaç: Bu çalışmanın amacı, iyi antrenmanlı yarı-profesyonel futbolcuların koşuya dayalı anaerobik sprint test (KAST) performanslarında diurnal varyasyonların olup olmadığını değerlendirmektir. **Gereç ve Yöntemler:** Çalışmaya katılan 25 futbolcunun yaş aralıkları 18-36 yıl iken, ortalama yaşları 20 yıldır. Ortalama ağırlıkları 72 (52-110) kg; ortalama boyları 176.92±6.17 cm; ortalama futbol tecrübeleri 8 (5-22) yıl ve ortalama haftalık antrenman süreleri de 6 (3-22) saattir. Futbolcuların kronotipleri, Horn-Östberg'in sabahçıl ve akşamcıl tipleri belirleme anket formu kullanılarak, ne akşamcıl ne de sabahçıl (ara tip) olarak belirlendi. Futbolcular, 1 hafta arayla 2 farklı günde olmak üzere 2 kez [ya sabah (8.30-10.00) ya da öğleden sonra (17.00-18.00)] Newtest Powertimer 300 serisi fotosel kullanılarak randomize çalışma dizaynında KAST için test edildi. Her test seansı öncesi hava sıcaklığı ve nem oranı ile oral vücut sıcaklığı, 24 saatlik besin kayıtları kaydedildi. **Bulgular:** Futbolcuların KAST değişkenlerinde diurnal varyasyonları analiz etmek için eşleştirilmiş örneklemler için t-testi kullanıldı. Maksimum güç (p>0,05), minimum güç (p>0,05), ortalama güç (p>0,05), yorgunluk indeksi (p>0,05), hava sıcaklığı (p>0,05), vücut ısısı ve kalori alımları (p>0,05) sabah ve akşam farklı değildi. **Sonuç:** Önceki araştırmaların aksine, futbolcuların KAST performanslarında diurnal varyasyon belirlenmedi. Bu durumun olası sebebi, katılımcıların kronotiplerinin ne sabahçıl ne de akşamcıl (ara tip) olmasına bağlandı. Bununla birlikte, bu çalışmanın sabahçıl veya akşamcıl kronotipli futbolcularla tekrarlanması farklı sonuçların elde edilmesini sebep olabilir.

Anahtar Kelimeler: Kronotip; diurnal ritimler; koşu temelli anaerobik sprint testi; futbol; sabahçıl-akşamcıl

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Many biological, biochemical, physiological, and psychological variables affect circadian rhythms, which refer to fluctuations in biological variables that repeat in a cyclical fashion over the course of a day.[1-6] Diurnal variations, changes in physiological or human performance measures during a normal waking day, are also part of the circadian rhythm.[6,7] Some individuals manifest being more energetic at a specific time of the day and such individual variations in circadian rhythms are described as chronotypes.[8-10] Based on chronotypes, individuals are classified as morning, evening, or neither chronotype.[11] The morning chronotype wakes up and goes to bed early, and their mental and physical performance is usually better in the first part of the day; whereas the evening chronotype gets up and goes to bed late and tends to show better mental or physical performance in the afternoon or evening.[8] The "Neither" types fall somewhere between the two.[9,12,13]

Athletic performance is affected by circadian rhythm as well as biological, biochemical, physiological, and psychological variables.[10,14-20] It has also been generally accepted that optimal athletic performance occurs during late afternoon-early evening rather than in the morning.[9,18-19,21-23] Moreover, daily variations in performance can be influenced by several factors such as sleep-wake patterns; core temperature and hormone rhythms; sleep inertia; age; fatigue perception; somatosensory inputs; chronotypes; etc.[14,17] Diurnal variations in physical performance have been partly attributed to natural fluctuations in core body temperature.[9,16,23] Although the exact mechanism to explain this relationship is not known, it has been suggested that higher body temperatures could enhance metabolic reactions, increase the extensibility of connective tissue, reduce muscle viscosity, and increase the conduction velocity of action potentials.[13,19,24] On the other hand, Teo, Newton, and McGuigan reported that an increase in body temperature could lead to an increase in carbohydrate utilization over fat as a fuel source, and possibly facilitate actin-myosin cross-bridge mechanics within the musculoskeletal unit.[25]

Soccer is a popular sport worldwide. Its competitive performance is dependent on physiological and metabolic variables.[26] Soccer involves several explosive movements such as accelerations, decelerations, changes in direction, as well as jumps, impacts, and shots.[26] These explosive movements are influenced by anaerobic power.[22,23]

Pullinger et al. reported diurnal variations in anaerobic power which they evaluated using a repeated sprint test on a non-motorized treadmill; found statistically significant differences in peak power (PP) and average power in the evening (5:30 PM) as compared to the morning (7:30 AM).[2,27] Similarly, Pavlovic et al. reported diurnal variations in anaerobic performance, including vertical jumps, changes in direction, and linear sprint tests (5.10, and 20 m) in the evening (6:00-7:30 PM) as compared to the morning (8:00-9:30 AM).[16] Chtourou et al. reported diurnal variations in anaerobic performance, and their evaluation using the Wingate-Test (WAnT) revealed higher PP and mean power (MP) values in the evening (5:00 PM) versus morning (7:00 AM).[19]

The running-based anaerobic sprint test (RAST) is a reliable and simple field test that can be easily performed; and which can adequately mimic the parameters of the repeated sprint test activity during field-based team sports.[28-30] This study examined whether the diurnal variations in the RAST performance in well-trained semi-professional male soccer players paralleled with their increasing body temperatures. We hypothesized that a) there were diurnal variations in body temperatures and the peak body temperature would be measured in the afternoon b) all RAST variables such as maximum power (P_{max}), minimum power (P_{min}), MP, and fatigue index (FI) would be better in the afternoon than in the morning, in parallel with increasing body temperature.

MATERIAL AND METHODS

STUDY DESIGN

According to the study design, data were recorded in a randomized, counterbalanced order. Caloric intake was collected 24 h prior to each test session, using a 24 h dietary recall sheet. Participants listed whatever they ate or drank, excluding supplements, alcoholic, or caffeinated drinks. The total intake of calories, including calories from carbohydrates were calculated by a licensed nutritionist. Each session

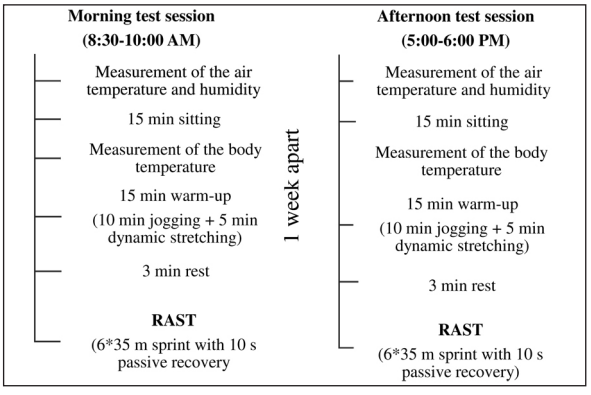

FIGURE 1: Research protocol.

began by sitting for 15 min, followed by an oral body temperature measurement. After that, each player performed a 15 min warm-up consisting of 10 min of jogging and 5 min of dynamic stretching. After the warm-up session, the players performed RAST twice, either in the morning (8:30-10:00 AM) or in the afternoon (5:00-6:00 PM) on two separate days that were one week apart. For the morning test sessions, players were instructed to wake up at 6:00 AM, while for the afternoon test sessions, they were instructed to finish their last meal at least 3 h prior to the test. Except for these instructions, the researchers did not intervene in the players' nutritional habits. The research protocol is presented in Figure 1.

PARTICIPANTS

P_{peak} morning value 10.76±1.05 was taken as a reference from the study of Hammouda et al. [4] according to this value, the number of subjects required for this study was determined as 25 with a level of d=0.41 deviation and significance set at α=0.05. Based on power analysis; twenty-five soccer players were recruited from a local soccer league for the study. Their descriptive characteristics are presented in Table 1. The study was conducted in accordance with the principles of the Declaration of Helsinki, and the study protocol was approved by Trakya University Ethics Committee [2019/115]. The players provided their written, informed consent prior to participation. The research protocol was explained in full, and any questions were answered before the study. Inclusion criteria comprised; a) having at least 5 years of soccer experience, b) being ≥18 years old, c) having a soccer license for the 2020 soccer season, d) no recent shift work, e) not taking any medications like antidepressants, etc. with the potential to affect the chronotype, f) being healthy in accordance with the medical examination for obtaining a soccer license for the 2020 season, g) no recent musculoskeletal injuries, and h) playing either the defense, midfield, or forward positions. Goalkeepers and players taking supplements like creatine, amino acids, etc. were excluded from the study. They were asked to refrain from strenuous physical activities, maintain their normal sleep habits, maintain their nutritional habits throughout the study, and avoid too much caffeine and alcohol intake 6 and 12 h, respectively, prior to testing.

Players Chronotypes

Player chronotypes were determined using the Turkish version of the Horn-Östberg morningness-eveningness personality questionnaire (tMEQ).[31] This instrument measures human circadian rhythms. The test-retest reliability coefficient of the tMEQ was reported as 0.84.[31] Players were evaluated as neither type (*n*=16), moderately morning type (*n*=6), and moderately evening type (*n*=3) on the basis of their answers to the tMEQ self-assessment questionnaire, which estimated their morningness-eveningness chronotype. Based on average tMEQ scores, the players were categorized as neither type (tMEQ score= 50.48±8.67). Since the average score of the tMEQ fell into "neither" personality type for the players' circadian phase types, RAST performance and body temperature were not confounded by the "morning" or "evening" chronotype.

TABLE 1: Descriptive characteristics of the players.

n=25	Mean±SD / median (minimum-maximum)
Age (years)	20 (18-36)
Weight (kg)	72 (52-110)
Height (cm)	176.92±6.17
MEQ Score	50.48±8.67
Soccer experience	8 (5-22)
Total training time - weekly	6 (3-32)

SD: Standard deviation;
MEQ: Horn-Östberg morningness-eveningness personality questionnaire.

Body Mass and Height

The body mass and height of the athletes were measured using a digital scale (Seca, 769, Turkey). Body mass and height were measured while the participants were barefoot and wearing short tights and short sleeve shirts.

Air Temperature and Humidity

These data were measured using an iPhone mobile phone-6S weather app. Morning test sessions were performed at an average of 7 °C (range=7-17) air temperature and with 89% (78-89) relative humidity. Afternoon test sessions were performed at an average of 11 °C (range= 8-20) air temperature and with an average of 63% (range= 46-79) relative humidity.

Body Temperature

Both the morning and afternoon test sessions began with 15 min of sitting. Body temperature was measured with an oral, digital clinical thermometer (Wee Baby, İstanbul, Turkey, accuracy ±0.1°C) inserted sublingually for at least 3 min.

Warm-up Session

Each test session started with a 15 min warm-up consisting of 10 min of jogging and 5 min of dynamic stretching exercises. During the jogging session, players ran 400 m five times without resting, and every 400 m was set as 3 min. The dynamic stretching sessions consisted of front kicks with hand reach, walking lunges, high knee skipping, butt kicks, and explosive leg swings.

The Running-based Anaerobic Sprint Test

This instrument is a reliable and simple test for field-based team sports.[28-30] According to Zacharogiannis et al. there were significant correlations between the RAST and the WAnT for PP and MP variables (r=0.82 and r=0.75, respectively) and the RAST can measure anaerobic capacity and power.[32] In this study, RAST was performed on an artificial turf and involved 6 maximal efforts sprints of 35 m, separated by a passive recovery period of 10 s. RAST variables like P_{max}, P_{min}, MP, and FI were calculated automatically using the Newtest Powertimer software. The time taken for each 35 m effort was recorded using a system photocell (Newtest Powertimer 300-series, Oy, Finland) both at the beginning and the end of the 35 m sprint. The Newtest Powertimer testing system has measured jump height and running speed successfully in a previous study.[33] In the Powertimer testing system, bias 0.996 (-0.4%), 95% limits of agreement x/÷1.015 (±1.5%) and p=0.156 were determined for the retest reliability at 0-40 m (s).[33]

STATISTICAL ANALYSES

Study data were analyzed using the software program IBM SPSS Statistics 22.0 for Windows (IBM Corporation, Armonk, NY, USA). PASS® statistical analysis software version 0.8.0.6 was used for calculating statistical power when determining sample size. Related data's normality assumption was checked using the Shapiro-Wilk test. When the data were normally distributed, parametric tests were used, and descriptive statistics were presented as mean±standard deviation. When the data were not distributed normally, non-parametric tests were used, and descriptive statistics were presented as median (25%-75% percentiles). The dependent groups were compared using the paired sample t-test and Wilcoxon test. The statistical significance level for all the analyses was set at α=0.05.

RESULTS

The descriptive characteristics of the players are presented in Table 1. Air temperature, humidity, total caloric intake, and calories from carbohydrates are presented in Table 2, that also reveals that there were no statistically significant differences between the morning and afternoon test sessions, except for the morning test session having a higher humidity than the afternoon session ($p<0.05$). RAST variables such as P_{max}, P_{min}, MP, and FI values did not differ between the morning and afternoon test sessions in terms of statistical meaningfulness ($p>0.05$) as seen in Table 3.

DISCUSSION

The study aimed to examine whether there were diurnal variations in the RAST performance of well-trained semi-professional male soccer players in parallel with increasing body temperature. We hy-

TABLE 2: Air temperature, humidity, total caloric intake, and calories from carbohydrates.

n=25	Morning test session	Afternoon testsession	p value
Air temperature (°C)	7 (7-17)	11 (8-20)	0.119
Humidity (%)	89 (78-89)	63 (46-79)	<0.001*
Body temperature (°C)	34.3 (33.8-37.9)	34.2 (33.8-38.0)	0.153
Total caloric intake (kcal)	2408.00±747.77	2248.12±666.31	0.189
Calories from carbohydrates (kcal)	912.24±338.31	884.00±299.82	0.635

*p<0.05.

TABLE 3: A comparison of RAST variables during the morning and afternoon test sessions.

n=25	Morning test session	Afternoon test session	p value
P_{max} (W)	277.40±37.88	293.26±6 3.43	0.211
P_{min} (W)	170.97±40.39	188.39±54.52	0.105
MP (W)	223.76±29.18	233.89±54.68	0.313
FI	2.3 (0.8-4.6)	2.3 (0.9-5.9)	0.726

P_{max}: Maximum power; P_{min}: Minimum power; MP: Mean power; FI: Fatigue index.

pothesized that a) there would be diurnal variations in body temperatures and that peak body temperature would be determined in the afternoon, b) all RAST variables such as P_{max}, P_{min}, MP, and FI would be better in the afternoon than in the morning in parallel with increasing body temperature.

This study's main finding was that there were no diurnal variations or variations in RAST variables (P_{max}, P_{min}, PM, and FI), or body temperature. Accordingly, this study's hypotheses were not confirmed. Pense E. Harbili and S. Harbili reported similar results, they noted diurnal variations in core body temperature, but not in skin surface or tympanic temperatures.[34] In addition to core body temperature diurnal variations favoring the early evening (4:00-5:00 PM), Pense, E. Harbili, and S. Harbili found no diurnal variations in any WAnT variables such as PP, MP, and FI. [34]

Contrary to the results of our study, many studies reported diurnal variations in body temperature parallel to physical or physiological performance in the afternoon or early evening. In these studies, diurnal variations were explained by body temperature peaking in the late afternoon.[4,8,10,14-16,20,22,27] Reilly et al. reported that the circadian rhythm of core temperature is often used as a marker of the body clock due to its strong endogenous component.[23] Drust et al. also argued that many measures of physical performance display circadian rhythms closely in phase with body temperature variations.[35] On the other hand, Masmoudi et al. argued that the time of the day, in addition to influencing athletic performance could affect mood and mental performance.[18] Similar to Masmouidi et al., Pullinger et al., also argued that both core body and muscle temperatures were determinants of diurnal variations in repeated sprint ability, and several other factors accounted for circadian variations such as motivational effects, subjective arousal, sleepiness, and hormones (cortisol, testosterone, and thyroid secretions).[18,27]

To the best of our knowledge, this study is the first to evaluate diurnal variations in soccer players' anaerobic performance using RAST since previous studies generally used tests like the WAnT, repeated sprint ability, agility, or linear sprints.[4,8,20,22,27,36] Why did the results show no diurnal variations in RAST? As argued above, there might have been several other factors (hormones, moods, mental performance, sleepiness, motivational factors, and subjective arousal) affecting diurnal variations in physical performance. Soussi et al. argued that the inclusion of a longer warm-up prior to testing could have diminished the magnitude of diurnal variations.[24] As in the study by Soussi et al., our players performed a 15 min active warm-up prior to each of the test sessions, and that could be the main reason for the results depicting the players as having mixed or neither chronotype.[24] Rae, Stephenson, and Roden proposed that mixed chronotypes, peak time-of-the-day performance in the morning and evening types could cancel each other out thus masking the diurnal variations in performance.[11]

The study had several limitations; a) While body temperatures of some players were low, others had relatively higher body temperatures than normal body temperature (see Table 2). These results may have been due to the thermometer used. If there were diurnal variations in any RAST variables; other independent variables such as air temperature, humidity, body temperature, total caloric intake, and calories from carbohydrate would gain importance in evaluating results, b) Since the players were recruited from several soccer clubs, they might have had different fitness levels and this situation might have affected this study's results, c) Having not used tools like the "Borg scale of Perceived Exertion," the self-rating alertness index, Hooper Index, or profile of mood state questionnaire before or after each of the test sessions; we assumed that all the players put in their maximal efforts to perform each 35 m sprint.

CONCLUSION

RAST performance had no diurnal variations parallel to oral body temperature in semi-professional, well-trained male soccer players with "neither" chronotype. On the basis of our study's results, soccer players can train or play matches either in the mornings or afternoons without any performance impairment. If the study was replicated with players recruited from the same soccer team and those with extreme chronotypes (morning or evening), the same research design could have produced different results.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Cem Kurt;* ***Design:*** *Cem Kurt;* ***Control/Supervision:*** *Cem Kurt;* ***Data Collection and/or Processing:*** *Zeliha Nur Kalyon;* ***Analysis and/or Interpretation:*** *Cem Kurt;* ***Literature Review:*** *Zeliha Nur Kalyon;* ***Writing the Article:*** *Cem Kurt, Zeliha Nur Kalyon;* ***Critical Review:*** *Cem Kurt;* ***References and Fundings:*** *Cem Kurt, Zeliha Nur Kalyon;* ***Materials:*** *Cem Kurt, Zeliha Nur Kalyon.*

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