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Strategic daytime napping enhances agility and lowers perceived exertion but does not improve fatigue resistance in adolescent soccer players

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Daytime naps are increasingly adopted by athletes to alleviate subjective fatigue and restore alertness, yet their impact on high-intensity anaerobic tasks remains unclear. Both nap duration and circadian timing may modulate psychomotor readiness, perceived exertion, and fatigue resistance, but evidence from team-sport settings is limited. This study aimed to determine how different daytime nap durations (25 vs. 45 min) influence agility, repeated-sprint performance, and psychophysiological responses—including perceived exertion and mood—in adolescent soccer players. Sixteen competitive male adolescent soccer players (all intermediate chronotypes) completed three randomized, crossover sessions: no nap (N0), 25-min nap (N25), and 45-min nap (N45). Nap compliance was objectively verified by actigraphy. After a 60-min post-nap wake-up period, participants performed the Pro Agility Test and a repeated-sprint ability (RSA) protocol. Psychophysiological outcomes included ratings of perceived exertion (RPE), Hooper Index, visual analogue scales (VAS) for alertness, and Profile of Mood States (POMS). Agility improved in a clear dose–response pattern (N0 = 5.40 ± 0.34 s; N25 = 5.18 ± 0.23 s; N45 = 4.98 ± 0.29 s; $p < 0.001$, $\eta p^2 = 0.57$). RPE was significantly lower after N45 versus N0 (Δ = −1.4; $p < 0.01$, $\eta p^2 = 0.45$). RSA indices showed no overall condition effect, although best sprint time improved after N45 versus N25 ($p < 0.01$) with greater fatigue accumulation across repeated sprints ($p < 0.05$). Mood analysis revealed positive associations between fatigue and RPE and negative associations between vigor and RPE, indicating that mood states are associated with perceived exertion. A 45-min early-afternoon nap meaningfully enhanced agility and reduced perceived exertion but did not improve fatigue resistance during repeated sprints. Coaches should weigh the neuromuscular and perceptual benefits of longer naps against potential fatigue trade-offs when designing pre-competition recovery strategies.

Keywords Daytime nap, Sleep inertia, Perceived exertion, Mood, Psychophysiology, Agility, Repeated-sprint ability, Chronotype

Sleep is a fundamental biological process with profound implications for physical recovery, cognitive function, and athletic performance[1–3]. In the context of high-performance sports, where repeated physical stress and limited recovery windows are common, optimizing sleep-related strategies has become an essential component of performance planning[4,5]. While the critical role of nocturnal sleep is well-established, emerging research has identified strategic napping as a viable intervention to supplement sleep, improve recovery, and enhance short-term physical and mental performance in athletes[6,7]. Daytime napping, when properly timed and dosed, may facilitate neuromuscular coordination, promote psychophysiological restoration, and attenuate perceived exertion levels[8,9]. Nevertheless, empirical findings remain inconsistent, particularly regarding anaerobic performance outcomes such as agility and repeated-sprint ability (RSA)[5,10,11].

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Several mechanisms have been proposed to explain the performance-enhancing effects of napping[3,12,13]. Naps that reach NREM stage 2 or deeper sleep stages are believed to contribute to memory consolidation, motor skill acquisition, and emotional regulation—processes that are critical to athletic execution[14,15]. Moreover, naps taken during the postprandial circadian dip (typically between 13:00 and 16:00) align with natural fluctuations in alertness and have been shown to mitigate the effects of sleep deprivation[16,17], reduce sleep inertia[18], and restore vigilance[19,20]. Sleep inertia, defined as a transient period of grogginess and impaired alertness following awakening, can undermine the potential benefits of napping if naps are excessively long or poorly timed[21]. Conversely, naps aligned with the circadian nadir in alertness, typically occurring in the early afternoon, can optimize post-nap cognitive and physical function by capitalizing on natural circadian dips and minimizing sleep inertia[22]. However, the benefits of napping appear to vary depending on individual differences in sleep architecture, nap duration, and biological rhythms. One of the most overlooked but increasingly relevant moderators in this domain is chronotype, the behavioral manifestation of circadian preference for activity and rest cycles[23,24].

Chronotype influences the timing of peak cognitive and physical performance. Morning-type individuals tend to perform optimally in the early hours of the day, while evening-types exhibit delayed peaks in performance and alertness[25]. Intermediate-types typically display more stable performance across the day[26]. A growing body of research suggests that aligning training and recovery strategies with an athlete's chronotype can optimize performance gains and reduce injury risk[25]. Biologically, evening types exhibit a delayed phase of melatonin release and core body temperature rhythm, which may shift their peak alertness and physical performance to later hours of the day. This misalignment with traditional training or testing schedules could theoretically influence their responsiveness to interventions[27,28]. However, despite growing awareness of chronobiological influences, limited attention has been paid to how these individual differences interact with acute recovery modalities such as strategic napping. Furthermore, many studies on napping in sports contexts have failed to control for chronotype or to systematically assess its role in moderating performance responses[7,29].

In soccer, success depends not only on aerobic endurance but also on explosive anaerobic qualities, such as agility, acceleration, and sprint capacity. These attributes are essential for rapid changes in direction, short-distance bursts, and high-intensity actions that are characteristic of match play[30,31]. Recovery protocols that target neuromuscular readiness and reduce psychological fatigue are therefore critical[32]. While studies have investigated the influence of various recovery methods, including cold-water immersion, active recovery, and nutritional strategies, napping has recently gained traction as a potential tool for improving readiness in team sports[33]. Preliminary evidence suggests that short naps can positively impact agility and reaction time[6], however, the findings remain equivocal, and research that incorporates repeated sprinting protocols, a key performance determinant in soccer, is scarce[5].

The present study was designed to extend existing research on daytime napping and athletic performance by addressing several unresolved aspects in a specific applied context[5]. Rather than examining the general effects of napping, this study focused on a dose–response comparison between two commonly used nap durations (25 vs. 45 min) within a homogeneous group of adolescent male soccer players. In addition, the investigation integrated multiple performance and psychophysiological outcomes by concurrently assessing agility, repeated-sprint ability (RSA), perceived exertion, and mood states[34–36]. This combined approach allows for a more comprehensive evaluation of how nap duration may differentially influence neuromuscular performance and subjective responses relevant to team-sport demands. Chronotype was assessed to characterize the sample and provide contextual interpretation, although no between-chronotype comparisons were intended. Collectively, this design aims to clarify the practical relevance of nap duration selection in youth soccer settings.

It was hypothesized that daytime napping would improve agility performance and reduce perceived exertion, with longer nap durations producing greater benefits. Given the multifactorial nature of repeated-sprint ability, no substantial changes in RSA performance were expected.

Materials and methods

Study design and participants

A quasi-experimental, repeated measures crossover design was employed to examine the acute effects of strategic napping on anaerobic performance in competitive male soccer players. All participants completed three experimental sessions separated by 48-hour intervals under randomized conditions: no nap (N0), 25-minute nap (N25), and 45-minute nap (N45).

Sample size determination was conducted using G*Power 3.1.9.7 software (Heinrich Heine University, Düsseldorf, Germany)[37]. A repeated-measures ANOVA (within-subjects design) with three conditions (no nap, 25-min nap, 45-min nap) was selected, with a significance level of $\alpha = 0.05$ and statistical power of $1\text{-}\beta = 0.80$. Based on medium-to-large expected effect sizes (Cohen's $f = 0.30–0.40$) reported in previous nap-related performance studies[38,39], the analysis indicated that at least 12 participants were required. To strengthen statistical power and account for variability, we recruited 16 competitive male soccer players, which exceeded the minimum requirement. The crossover design further enhanced sensitivity, as each participant served as his own control, thereby increasing power relative to a between-subjects design[40].

All participants were competitively active players from the U17 and U19 teams of Yeni Malatyaspor, recruited at the conclusion of the competition season to minimize training- and competition-related confounding variables. All testing sessions were conducted during the off-season period to minimize the influence of competitive fatigue. Baseline anthropometric characteristics including age, height, body weight, and body mass index (BMI) were recorded for all participants (Table 1). Participants demonstrated extensive soccer experience, having initiated competitive play at a mean age of 9.06 ± 2.0 years.

Inclusion criteria were: (a) being a member of the Yeni Malatyaspor U19 or U17 team, (b) having no history of illness or injury, and (c) no regular napping habit. Participants were excluded if they reported a regular

Participants	1st protocol	2nd protocol	3rd protocol
Participant 1	N0	N25	N45
Participant 2	N0	N25	N45
Participant 3	N0	N25	N45
Participant 4	N0	N45	N25
Participant 5	N0	N45	N25
Participant 6	N0	N45	N25
Participant 7	N25	N0	N45
Participant 8	N25	N0	N45
Participant 9	N25	N0	N45
Participant 10	N25	N45	N0
Participant 11	N25	N45	N0
Participant 12	N45	N0	N25
Participant 13	N45	N0	N25
Participant 14	N45	N25	N0
Participant 15	N45	N25	N0
Participant 16	N45	N25	N0

Table 1. The order of implementation of the protocols in a balanced design among the participants. N0: no strategic nap, N25: 25 min strategic nap, N45: 45 min strategic nap.

daytime napping habit. Regular napping was operationally defined as engaging in daytime naps on three or more days per week for at least the previous three months, as determined by self-report during the initial screening. Exclusion criteria to ensure internal validity and robustness of results included: (a) active infections, (b) hyperactivity, (c) sleep disorders, and (d) sleep problems on protocol days. Additionally, participants who failed to follow instructions, had difficulty adhering to protocols, or were unable to cooperate during the procedures were excluded. These criteria ensured that the sample consisted of healthy, voluntary soccer players with no confounding health conditions. All participants were instructed to sleep at least 7 h the night before each testing session and refrain from caffeine intake for at least 6 h prior to arrival, in order to minimize external influences on sleepiness and performance[20,38].

All participants and, for those under 18 years, their parents or legal guardians provided written informed consent. The study protocol was approved by the Inonu University Non-Interventional Clinical Research Ethics Committee (Approval No: 2024/5635, Date: 05/03/2024) and conducted in accordance with the Declaration of Helsinki.

Experimental design

Prior to the intervention, participants completed three familiarization sessions to acclimate to the nap protocols and testing procedures. Participants then attended three test sessions involving different nap conditions: no nap (N0), 25-minute nap (N25), and 45-minute nap (N45). A 48-hour recovery period was maintained between sessions[41]. Upon arrival, participants were allowed a 10-minute adaptation period in the sleep environment[7]. Nap opportunities were provided in a quiet, darkened room maintained at ~ 22 °C[42]. To ensure compliance with the nap protocol, participants were equipped with a wrist-worn Fitbit Charge 6 device (Fitbit Inc., San Francisco, CA, USA) during all experimental sessions. Sleep onset, nap duration, and wake time were objectively verified from Fitbit-derived actigraphy data. This procedure confirmed that participants slept during the 25-min and 45-min nap conditions and remained awake during the no-nap condition. Participants refrained from visually or cognitively stimulating activities and rested passively in a seated position during the standardized 60-min post-nap period, with only water permitted[43,44]. The order of the nap conditions was randomized using a crossover design, and the protocol sequences for each participant are presented in Table 1.

To reduce the effects of sleep inertia, performance testing began 60 min after awakening[45,46]. Heart rate during warm-up was monitored using a Polar H10 sensor to ensure standardization[47]. The warm-up protocol began with light jogging and was followed by a 3-minute sequence of mobility exercises, including foot scans, toe and ankle rotations, lateral trunk stretches, torso rotation stretches, hip circles, and knee bends. After warm-up, participants completed the Pro Agility Test followed by the Repeated-Sprint Ability (RSA) Test, with RPE ratings recorded after each sprint. A three-minute rest was provided between the two anaerobic tests (Fig. 1).

Anthropometric measurements

Participants were assessed barefoot and standing using a SECA® stadiometer (GmbH, Hamburg, Germany). The Frankfurt plane was used to ensure accurate head positioning. Weight was measured using a Toledo 2096 PP scale (São Bernardo do Campo, Brazil), and participants wore light clothing during assessment. BMI was calculated as weight (kg) divided by height squared (m^2)[48].

Morningness–Eveningness questionnaire (MEQ)

The MEQ is a validated self-report instrument that classifies individuals based on their preferred activity times. The scale consists of 19 items, with total scores ranging from 16 to 86. Scores of 16–41 indicate evening

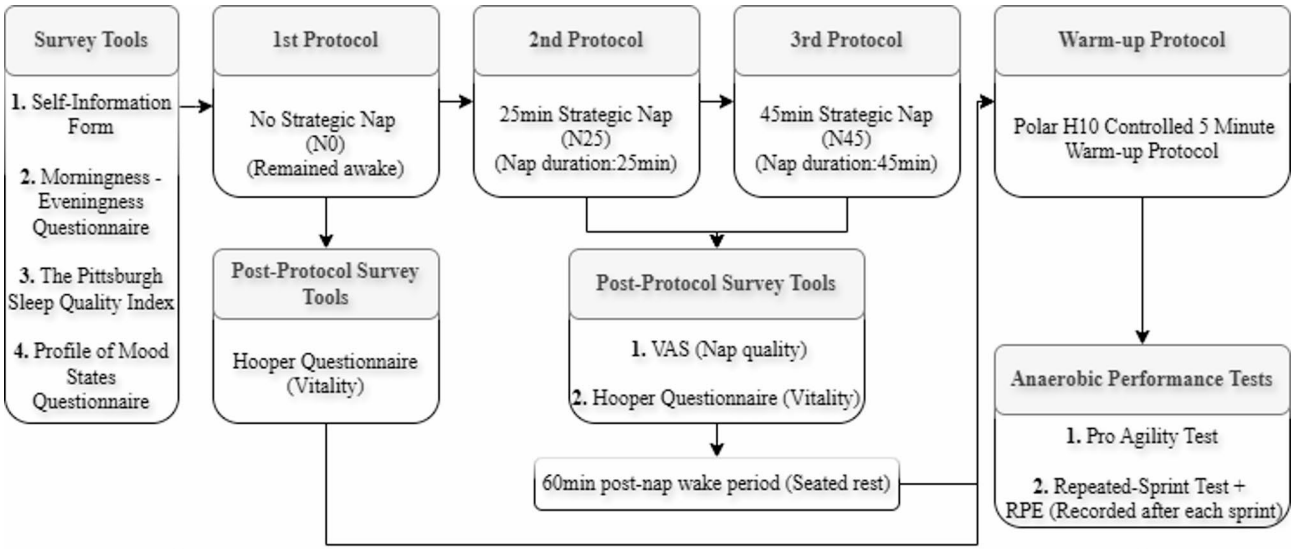

Fig. 1. Experimental design of study.

type, 42–58 intermediate type, and 59–86 morning type. The MEQ was administered at the beginning of the study, prior to the implementation of nap protocols, under the supervision of the research team. Participants completed the scale individually in a distraction-free environment. According to MEQ results, all 16 participants were classified as intermediate type. The MEQ has demonstrated strong internal consistency and reliability in multiple populations[49,50].

Hooper questionnaire

The Hooper Index evaluates subjective perceptions of fatigue, stress, muscle soreness (rated from 1 = very low to 7 = very high), and sleep quality (1 = very good to 7 = very poor). This tool provides a snapshot of overall wellness and recovery status. In this study, participants completed the Hooper Questionnaire after each nap protocol to assess perceived recovery[51].

Pittsburgh sleep quality index (PSQI)

The PSQI assesses subjective sleep quality over the past month using 19 self-report items divided into seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The global score ranges from 0 to 21, with higher scores indicating poorer sleep quality[49].

Profile of mood states (POMS)

POMS evaluates mood states across six dimensions: tension, depression, anger, vigor, fatigue, and confusion. The version used in this study included 58 items rated on a 5-point Likert scale (0 = not at all, 4 = extremely). Participants reported their mood states based on the past week, including the test day[52,53].

Pro agility test

The Pro Agility Test (20-yard shuttle run) evaluates change-of-direction speed. Participants started from the center point, ran 5 yards to the left, then 10 yards to the right, and finally 5 yards back to the center. The total distance was 18.28 m, and the time to complete the sequence was recorded[54]. Agility and RSA timings were recorded using a dual-beam electronic timing system (SmarTracks, Germany) with a sampling frequency of 1,000 Hz, positioned at the start and finish lines at hip level. This minimized human error and ensured millisecond precision.

Repeated-sprint ability (RSA) test

The RSA test measures an athlete's ability to repeatedly produce maximal sprint efforts with limited recovery. This study employed 6 × 30-meter sprints with 20-second rest intervals between each sprint, a protocol commonly used in team sports to assess anaerobic endurance[55,56].

Rate of perceived exertion (RPE)

RPE was assessed using the Borg Scale (6–20), which captures the participant's subjective effort during physical activity. RPE was recorded immediately after each sprint during the RSA Test, and the average RPE score represented overall perceived exertion for the session[26].

Parameters	x ± SD	Min	Max	Skewness	Kurtosis
Age (year)	17.18 ± 1.04	16.00	19.00	-0.948	0.375
Height (cm)	179.06 ± 3.17	173.00	183.00	-0.623	-0.581
Weight (kg)	71.50 ± 7.16	60.00	85.00	-0.732	0.275
BMI (kg/m2)	22.28 ± 1.98	19.10	26.50	0.134	0.475
HR (beats)	94.00 ± 14.38	64.00	120.00	0.692	-0.437
PSQI (score)	5.37 ± 2.62	2.00	13.00	4.08	1.794
POMS Total Mood (score)	42.25 ± 35.10	-1.00	117.00	-0.703	0.574

Table 2. Demographic information of participants. Values are presented as mean ± standard deviation ($\bar{x}$ ± SD). HR: Heart Rate, PSQI: Pittsburgh Sleep Quality Index, POMS: Profile of Mood States.

Outcome	N0 (Mean ± SD)	N25 (Mean ± SD)	N45 (Mean ± SD)	*p* value	ηp^2
Pro agility test (s)	5.40 ± 0.34	5.18 ± 0.23	4.98 ± 0.29	< 0.001	0.57
RPE (score)	9.90 ± 1.65	9.07 ± 1.66	8.48 ± 1.35	< 0.001	0.45

Table 3. Primary performance outcomes across nap conditions. N0: no nap; N25: 25-min nap; N45: 45-min nap; RPE: Rate of Perceived Exertion. Lower values indicate better performance.

Outcome	N0 (Mean ± SD)	N25 (Mean ± SD)	N45 (Mean ± SD)	*p* value	ηp^2
Best sprint (s)	4.42 ± 0.26	4.53 ± 0.20	4.33 ± 0.19	0.074	0.11
Mean sprint (s)	4.70 ± 0.26	4.78 ± 0.31	4.70 ± 0.25	0.162	0.12
Sprint decrement (%)	6.36 ± 3.04	5.64 ± 4.15	8.72 ± 4.49	0.093	0.10
Hooper index	13.25 ± 3.31	15.50 ± 4.06	14.87 ± 4.73	0.072	0.16
VAS (alertness)	–	5.18 ± 2.48	5.37 ± 3.00	0.819	0.004

Table 4. Secondary RSA and recovery-related outcomes. VAS: Visual Analogue Scale. No significant main effects were observed for these variables.

Visual analogue scale (VAS) for sleep quality

Subjective sleep quality and alertness were assessed using a 100-mm visual analogue scale (VAS). For sleep quality, the scale was anchored from "slept very poorly" to "slept very well," whereas for alertness the anchors ranged from 0 = "extremely sleepy" to 100 = "fully alert." Participants marked a point along the line corresponding to their perceived state, and the distance from the left anchor was measured in millimeters to obtain a quantitative score[7].

Statistical analysis

Statistical analyses were performed using SPSS version 29. Descriptive statistics (mean, standard deviation, minimum, maximum) were calculated for demographic data. Normality of the data was confirmed using skewness and kurtosis values (within ± 1.5). Levene's test was applied to check for homogeneity of variance. Mauchly's test was used to assess sphericity. Where sphericity was violated, Greenhouse–Geisser (GG) corrections were applied and adjusted degrees of freedom are reported. In addition to partial eta squared (ηp^2), pairwise comparisons were supplemented with Cohen's dz effect sizes and 95% confidence intervals. Repeated measures ANOVA was used to compare performance parameters (Pro Agility, RSA, RPE, Hooper Index, VAS) across the three nap conditions (N0, N25, N45). Bonferroni post-hoc corrections were applied where appropriate. Effect sizes were reported using partial eta squared (ηp^2), interpreted as small ($\eta p^2 < 0.06$), medium ($0.06 \leq \eta p^2 < 0.14$), or large ($\eta p^2 \geq 0.14$)[40,57]. Pearson's correlation analyses were used to assess the relationships between PSQI and POMS scores and nap condition outcomes[58].

Results

Sixteen competitive male soccer players participated in this study. Participants ranged in age from 16 to 19 years (mean = 17.18 ± 1.04 years), with heights between 173 and 183 cm (mean = 179.06 ± 3.17 cm), and body weights ranging from 60 to 85 kg (mean = 71.50 ± 7.16 kg). The body mass index values fell within the normal range for athletes, spanning 19.10 to 26.50 kg/m² (mean = 22.28 ± 1.98 kg/m²). The baseline physiological and psychological assessments are presented in Table 2. According to the MEQ, all participants were classified as having intermediate chronotypes.

Tables 3 and 4 present the performance outcomes across the three napping conditions, with primary outcomes (agility performance and perceived exertion) summarized in Table 3 and secondary outcomes related to repeated-sprint ability and recovery indices presented in Table 4.

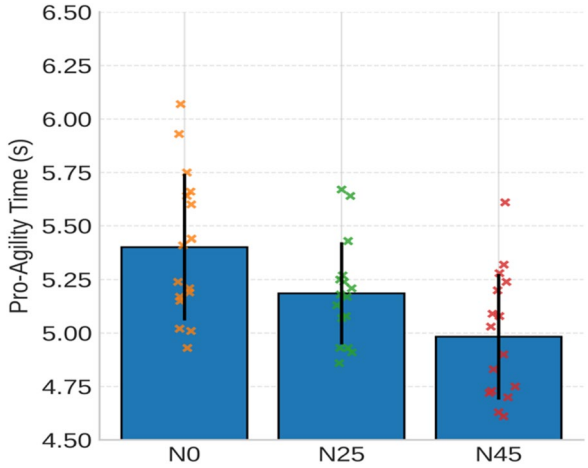

Fig. 2. Pro-agility performance across nap conditions (N0, N25, N45).

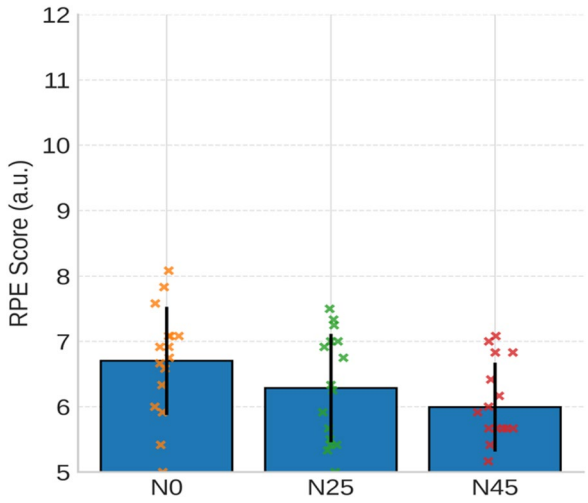

Fig. 3. Ratings of perceived exertion (RPE) across nap conditions.

A significant main effect of nap condition was observed for agility performance ($F(2,30) = 19.88$, $p < 0.001$, $\eta p^2 = 0.57$; Table 3). Post-hoc comparisons indicated that Pro Agility Test times were significantly slower in the no-nap condition compared with both the 25-min and 45-min nap conditions ($p < 0.01$), and that performance following the 25-min nap was slower than after the 45-min nap ($p < 0.05$). These findings demonstrate a clear dose–response relationship, with longer nap duration associated with progressively greater improvements in change-of-direction performance.

Secondary outcomes related to repeated-sprint ability are summarized in Table 4. Mean sprint time and total sprint time did not differ significantly across nap conditions ($p > 0.05$). Although moderate effect sizes were observed for best sprint performance ($F(2,30) = 2.76$, $p = 0.074$, $\eta p^2 = 0.11$) and sprint decrement ($F(2,30) = 2.50$, $p = 0.093$, $\eta p^2 = 0.10$), the overall condition effects did not reach statistical significance.

Ratings of perceived exertion differed significantly across nap conditions ($F(2,30) = 12.16$, $p < 0.001$, $\eta p^2 = 0.45$; Table 3), with RPE values significantly lower following the 45-min nap compared with the no-nap condition ($p < 0.01$). In contrast, Hooper Index scores showed numerically higher values following the 25-min nap, although this difference did not reach statistical significance ($F(2,30) = 2.88$, $p = 0.072$, $\eta p^2 = 0.16$; Table 4). Subjective alertness assessed by visual analogue scale did not differ between nap conditions ($p > 0.05$; Table 4).

Figure 2 illustrates the progressive improvement in Pro-Agility Test performance as nap duration increased. Mean agility times were 5.40 ± 0.34 s in the no-nap (N0), 5.18 ± 0.23 s in the 25-min nap (N25), and 4.98 ± 0.29 s in the 45-min nap (N45) conditions.

Figure 3 depicts RPE values across nap conditions, with lower scores observed following the 45-min nap compared with the no-nap condition. A significant main effect of condition was observed, $F(2,30) = 12.155$, $p < 0.001$, $\eta p^2 = 0.45$. Post-hoc comparisons demonstrated a clear downward trend, whereby RPE scores decreased as nap duration increased. The most pronounced difference emerged between the no-nap (N0) and 45-min nap (N45) conditions ($\Delta = 1.417$, SE = 0.287, $p = 0.001$, 95% CI = 0.644–2.189). By contrast, no statistically significant

differences were detected between N0 and N25 or between N25 and N45 ($p > 0.05$). Furthermore, Hooper Questionnaire scores did not vary as a function of nap duration ($p > 0.05$), suggesting that while subjective exertion during performance was sensitive to napping interventions, broader perceptions of recovery status were not affected.

Figure 4 presents individual responses for best sprint time (left y-axis) and sprint decrement (right y-axis) during the repeated-sprint ability (RSA) test across nap conditions (N0, N25, N45). Bars represent mean values, and individual data points illustrate inter-individual variability. No significant overall condition effects were detected. These patterns illustrate variability in specific RSA indices across conditions, although overall repeated-sprint ability performance remained largely unchanged.

Figure 5 illustrates participants' visual analogue scale (VAS) scores for subjective alertness across nap durations. Mean VAS ratings were 5.19 ± 2.48 following the 25-min nap and 5.38 ± 3.01 following the 45-min nap, with no statistically significant difference between conditions ($p > 0.05$). Individual data points show variability in responses across participants, with both increases and minimal changes observed following each nap condition.

Figure 6 presents the Hooper Index scores across nap conditions (N0, N25, N45). Mean scores showed minor fluctuations between conditions, but no statistically significant differences were detected ($p > 0.05$). The individual data points illustrate a broad range of responses, with some participants reporting higher fatigue or stress and others lower values, yet without a consistent trend attributable to nap duration. These findings indicate that, in contrast to agility and perceived exertion, the Hooper Index—which reflects subjective recovery status—remained stable irrespective of whether participants engaged in a 25-min or 45-min nap.

A significant negative correlation was observed between PSQI global scores and RSA best sprint time in the N0 condition ($r = -0.504$, $p < 0.05$), suggesting that better sleep quality was associated with improved repeated sprint performance in the no-nap condition. No significant correlations were found in the N25 or N45 protocols (Table 5). Statistically meaningful correlations discussed in the text are highlighted in bold to improve readability.

Further correlation analyses between POMS dimensions and performance parameters revealed that fatigue scores were positively correlated with RPE values in both the N0 ($r = 0.584$, $p < 0.01$) and N25 ($r = 0.564$, $p < 0.01$)

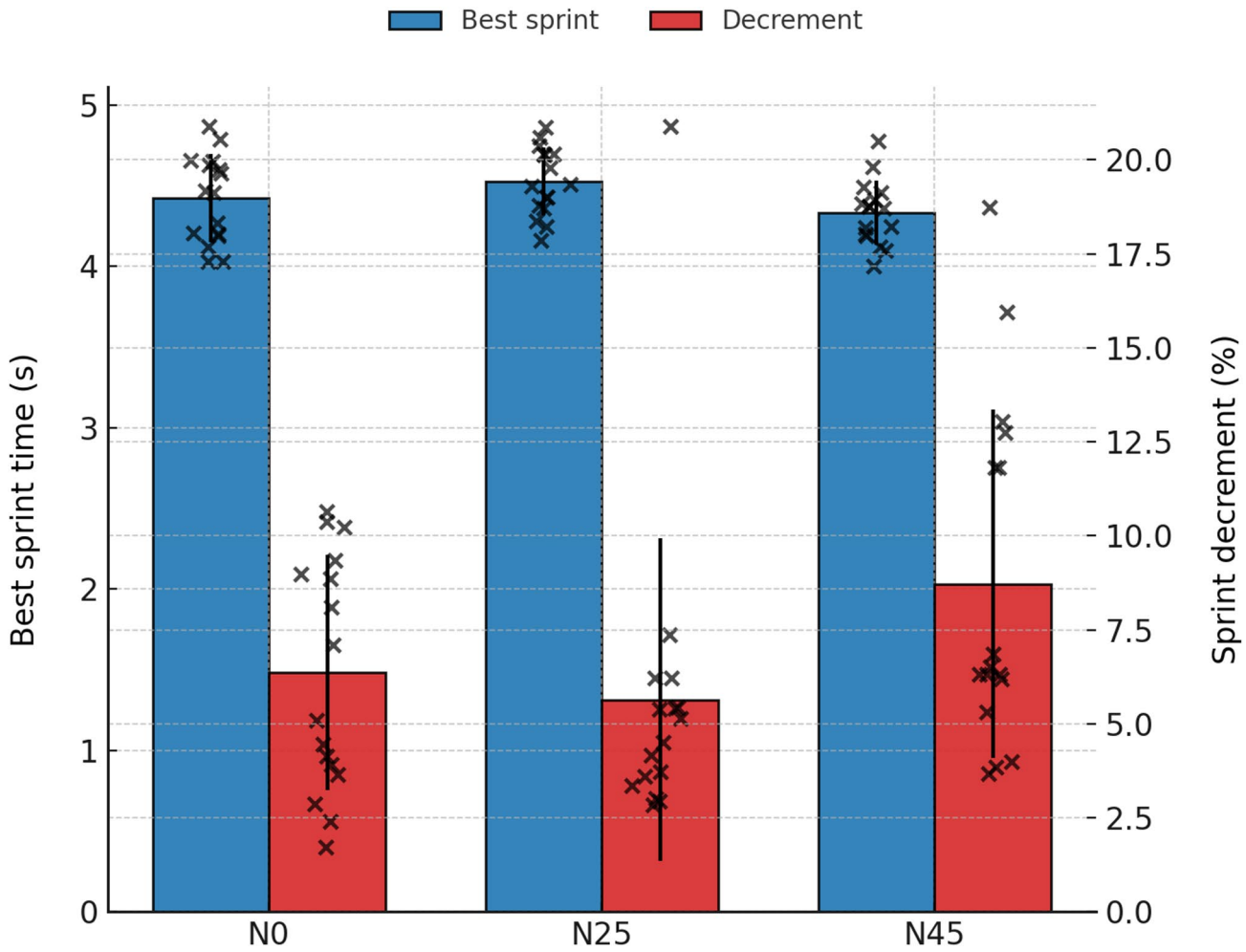

Fig. 4. Best sprint time and sprint decrement during the repeated-sprint ability (RSA) test across nap conditions.

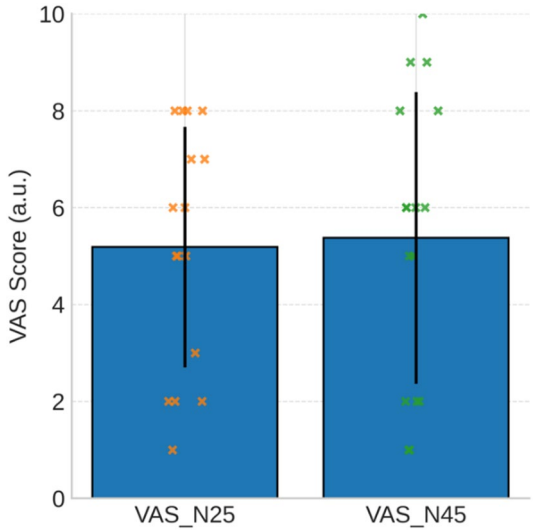

Fig. 5. Visual analogue scale (VAS) scores of subjective alertness.

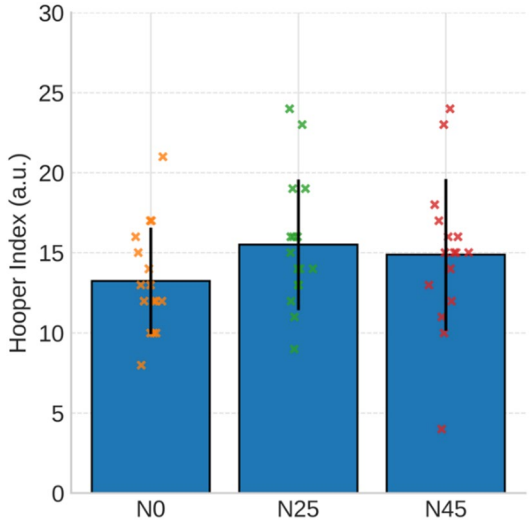

Fig. 6. Hooper index scores of recovery status.

protocols. In addition, vigor scores were negatively correlated with RPE scores in N45 (r = -0.507, $p < 0.05$), indicating that better mood states were associated with lower perceived exertion following longer naps (Table 6). Additional correlations are presented in Table 5 to provide a broader exploratory overview of the relationships between sleep, mood, and performance variables. Statistically meaningful correlations discussed in the text are highlighted in bold to improve readability.

Discussion

This study aimed to investigate the effects of strategic nap duration on anaerobic performance parameters in young male soccer players while considering psychological factors. The findings revealed that nap duration significantly influenced agility performance and perceived exertion levels in athletes without a habitual daytime napping routine, while no significant changes were observed in RSA performance. These results contribute to the literature by elucidating how short and controlled rest intervals interact with acute anaerobic performance in sport-specific populations. Notably, this study stands out for its multidimensional methodological approach and consideration of individual factors when examining the impact of strategic napping in sports science. It supports prior studies that simultaneously evaluated the physiological and psychological effects of nap duration using various methodological frameworks[9,10,39,51,59].

The observed improvements in agility performance with increased nap duration are consistent with previous findings[22,60], supporting the positive effects of strategic napping on psychomotor reaction time and neuromuscular coordination. The gradual improvements noted from 25 to 45 min of napping indicate that

	PT	P1	P2	P3	P4	P5	P6	P7	H-N0	H- N25	H- N45	PA- N0	PA- N25	PA- N45	RSA- N0	RSA- N25	RSA- N45	RPE- N0	RPE- N25	RPE- N45	VAS- N25	VAS- N45
PT	1																					
P1	0.829 <0.001	1																				
P2	0.661 0.005	0.637 0.008	1																			
P3	0.035 0.898	-0.147 0.586	0.127 0.639	1																		
P4	0.404 0.121	0.132 0.626	0.114 0.675	0.00 1.0	1																	
P5	0.508 0.045	0.390 0.135	0.018 0.948	-0.07 0.798	-0.06 0.819	1																
P6	0.773 <0.001	0.808 <0.001	0.603 0.013	-0.18 0.499	-0.16 0.546	0.483 0.058	1															
P7	0.611 0.012	0.478 0.061	0.137 0.612	-0.54 0.031	0.220 0.413	0.308 0.246	0.592 0.016	1														
H-N0	0.516 0.041	0.568 0.022	0.266 0.320	-0.46 0.068	-0.04 0.856	0.514 0.042	0.623 0.010	0.590 0.016	1													
H-N25	0.218 0.417	0.291 0.274	0.228 0.396	-0.33 0.202	-0.30 0.257	0.013 0.963	0.492 0.053	0.503 0.047	0.559 0.025	1												
H-N45	0.063 0.817	0.256 0.335	0.230 0.391	0.00 1.0	-0.58 0.017	0.056 0.835	0.458 0.074	0.059 0.829	0.346 0.189	0.752 0.001	1											
PA-N0	0.154 0.569	-0.020 0.942	-0.054 0.844	-0.12 0.637	0.696 0.003	-0.06 0.822	-0.18 0.540	0.120 0.659	-0.05 0.840	-0.47 0.063	-0.63 0.008	1										
PA-N25	0.010 0.970	0.022 0.936	-0.064 0.815	-0.03 0.905	0.361 0.170	-0.09 0.738	-0.11 0.664	-0.10 0.711	-0.24 0.364	-0.41 0.113	-0.35 0.175	0.634 0.008	1									
PA-45	0.112 0.680	0.123 0.650	0.239 0.374	0.100 0.927	0.334 0.206	-0.17 0.519	0.043 0.874	-0.22 0.409	-0.32 0.223	-0.21 0.415	-0.14 0.605	0.456 0.076	0.811 <0.001	1								
RSA-N0	0.351 0.182	**0.501** 0.048	0.356 0.176	0.02 0.927	-0.07 0.775	0.226 0.399	0.428 0.098	0.082 0.762	0.218 0.417	-0.05 0.842	0.148 *0.584*	0.325 0.220	0.409 0.116	0.458 0.075	1							
RSA-N25	0.652 0.006	0.680 0.004	0.403 0.121	0.007 0.980	-0.00 0.974	0.329 0.213	0.746 0.001	0.451 0.080	0.566 0.022	0.269 0.313	0.272 0.309	0.196 0.466	0.080 0.769	0.141 0.602	0.720 0.002	1						
RSA-N45	0.606 0.013	0.649 0.007	0.440 0.088	0.045 0.867	-0.05 0.852	0.378 0.149	0.674 0.004	0.323 0.222	0.450 0.081	0.042 0.876	0.055 0.839	0.263 0.324	0.118 0.662	0.170 0.530	0.792 <0.001	0.918 <0.001	1					
RPE-N0	-0.101 0.710	0.250 0.350	-0.043 0.874	-0.24 0.364	-0.31 0.233	0.187 0.487	0.069 0.800	-0.12 0.659	0.186 0.489	-0.05 0.834	-0.05 0.843	-0.34 0.188	0.013 0.962	-0.06 0.816	0.014 0.958	-0.13 0.623	0.000 0.999	1				
RPE-N25	-0.281 0.291	-0.053 0.846	-0.285 0.285	-0.34 0.193	0.086 0.751	0.003 0.991	-0.27 0.295	-0.19 0.461	-0.07 0.774	-0.18 0.489	-0.26 0.330	-0.00 0.993	0.479 0.060	0.335 0.204	-0.15 0.557	-0.44 0.086	-0.38 0.143	0.699 0.003	1			
RPE-N45	-0.272 0.307	-0.025 0.927	-0.337 0.202	-0.42 0.105	-0.16 0.541	-0.00 0.993	-0.12 0.635	0.052 0.848	0.082 0.763	0.025 0.926	-0.21 0.417	-0.07 0.783	0.327 0.217	0.156 0.565	0.007 0.981	-0.15 0.557	-0.05 0.840	0.728 0.001	0.791 <0.001	1		
VAS-N25	-0.542 0.030	-0.450 0.080	-0.229 0.394	0.202 0.453	-0.18 0.503	-0.10 0.713	-0.45 0.080	-0.74 0.001	-0.38 0.139	-0.67 0.004	-0.30 0.252	0.303 0.253	0.442 0.086	0.360 0.171	0.278 0.297	-0.16 0.533	0.017 0.949	0.115 0.671	0.234 0.384	0.116 0.669	1	
VAS-N45	-0.137 0.613	-0.277 0.298	-0.439 0.089	-0.06 0.823	0.299 0.261	0.140 0.606	-0.38 0.138	0.033 0.904	-0.08 0.758	-0.52 0.038	-0.70 0.002	0.420 0.106	0.519 0.039	0.105 0.698	−0.03 0.888	−0.17 0.526	−0.06 0.817	0.302 0.256	0.510 0.044	0.564 0.023	0.320 0.227	1

Table 5. Exploratory correlation between PSQI scores and nap durations. PT: Total Pittsburgh Sleep Quality Score, P1/2/3/4/5/6/7: Pittsburgh Component Scores, H: Hooper Index, PA: Pro Agility Test, RSA: Repeated-Sprint Ability Test, RPE: Rate of Perceived Exertion, VAS: Visual Analogue Scale, N0: No nap, N25: 25 min nap, N45: 45 min nap.

agility performance is sensitive to nap duration when naps are implemented within a realistic training-day time window[61]. The afternoon timing of the intervention may have further reinforced this effect. While research increasingly demonstrates the effects of nap duration on physical performance, the most pronounced effects are observed in motor-skill-specific outcomes, such as agility. The present findings are notably aligned with those of Eken et al. (2025), who assessed the acute effects of 25- and 60-minute naps on agility and vertical jump performance in elite youth soccer players[5]. In both studies, napping positively affected agility performance but did not significantly alter the explosive strength outcomes. Agility performance improved significantly after naps in athletes without a habitual napping routine, with the most pronounced benefits observed following the 45-min nap. Such findings align with previous reports showing that naps of 30–60 min can enhance motor performance requiring rapid changes of direction and coordination.

In contrast to agility, the repeated-sprint ability outcomes did not demonstrate clear between-condition differences. Although mean and total sprint times remained stable across nap conditions, moderate effect sizes emerged for best sprint and sprint decrement. Post-hoc analyses revealed that best sprint time was significantly faster following the 45-min nap compared to the 25-min nap, while sprint decrement was significantly higher after the 45-min nap compared to the no-nap condition and tended to be higher than the 25-min nap. These findings indicate that repeated-sprint ability outcomes were less responsive to nap duration than agility performance.

Beyond physical performance, perceptual responses also varied between nap conditions. RPE scores were significantly lower in the 45-min condition compared to the no-nap condition, indicating a reduced perception of effort despite similar external loads. The Hooper Index showed a tendency to increase following the 25-min nap. All participants were classified as intermediate chronotypes, which limited the ability to examine chronotype-related differences. Accordingly, the present findings reflect responses to strategic napping in a sample of athletes who did not regularly engage in daytime naps.

The 45-minute nap protocol not only improved agility but also reduced RPE. Despite the similar age groups in both studies, the RSA test employed in the present study provided a more complex assessment of anaerobic capacity, yielding no significant changes. Eken et al. (2025) similarly found no improvements in vertical jump performance, reinforcing the notion that napping primarily benefits coordination-based tasks like agility rather than power or endurance-related outcomes[5].

In contrast, VAS and Hooper Index scores did not significantly differ across nap durations, suggesting that subjective alertness and general recovery status may be less sensitive to short-term napping compared to agility and perceived exertion. These findings are in line with previous reports showing that subjective recovery markers often demonstrate weaker responsiveness than objective performance outcomes[7,32].

The current findings underscore that neuromuscular coordination and psychomotor speed may be more sensitive to short naps than anaerobic endurance. This aligns with Forster et al. (2022), who highlighted agility improvements through sprint, plyometric, and resistance training, although these interventions rarely consider chronophysiological factors such as sleep or circadian rhythm[62]. Thus, this study may fill this gap by demonstrating how recovery-based strategies, such as strategic napping, can acutely enhance performance. While previous literature has proposed several physiological explanations for nap-related performance changes, the present study did not directly assess underlying biological mechanisms[63].

Strategic napping also significantly decreased perceived exertion, indicating that psychological strain induced by agility-specific training may be alleviated by naps. These outcomes are congruent with the comprehensive review by Haitong Yu et al. (2025), which emphasized the benefits of napping in alleviating perceived effort, enhancing agility, and compensating for inadequate nighttime sleep[64]. The improvements in Pro Agility performance and reductions in RPE scores following 25- and 45-minute naps support the recommendation for a 60-minute post-nap buffer period, as reported in the literature. However, both Yu et al. (2025) and the present study reported limited effects of naps on RSA performance.

Likewise, the present findings align with Souabni et al. (2023), who observed that napping benefits physical performance but that the magnitude of this effect depends on nap duration, timing, and test type[39]. The current study also explores mood, an often-overlooked factor with growing recognition in performance research[65,66]. The positive correlations observed between fatigue-related mood dimensions and RPE scores highlight the indirect effects of mood on exercise performance. While this study did not report high-intensity emotional fluctuations, it does challenge prior assumptions by showing that 45-minute naps yielded comparable outcomes to longer naps in previous studies, particularly in contexts with low affective intensity[9,66].

Similarly, Hammouda et al. (2018) reported improvements in RAST performance and hematological markers following naps[34], although the mechanisms differed—biochemical versus psychological. Although all participants were classified as intermediate chronotypes, performance changes were observed following different nap durations. The positive relationship between mood dimensions and performance—especially between fatigue and RPE—provides new insights into the interplay between sleep, mood, and exertion perception[67].

Additional literature support comes from BenSalem et al. (2025), who found that 40- and 90-minute naps improved shuttle-run performance, mood, and RPE in female athletes[68]. Lastella et al. (2021) also concluded that naps can enhance physical, cognitive, and psychological outcomes, especially when taken between 13:00 and 16:00 with at least 30 min of post-nap wakefulness[6], a timing adhered to in this study.

The comparison between the 25-min and 45-min nap durations also carries practical relevance for athletes without a habitual daytime napping routine. Short naps of approximately 20–30 min are frequently recommended in applied settings due to their ease of implementation and lower likelihood of post-nap sleep inertia, making them suitable for use between academic obligations and training sessions. In contrast, the 45-min nap represents a longer, yet still realistic, daytime sleep opportunity that may allow for more pronounced recovery-related benefits.

This study is not without limitations. Although polysomnography remains the gold standard for identifying sleep stages, nap compliance in this study was verified using wrist-worn Fitbit Charge 6 actigraphy, which

	P-Ten	P-Dep	P-Ang	P-Vig	P-Fat	P-Con	P-TM	H-N0	H- N25	H- N45	PA- N0	PA- N25	PA- N45	RSA- N0	RSA- N25	RSA- N45	RPE- N0	RPE- N25	RPE- N45	VAS- N25	VAS- N45
P-Ten	1																				
P-Dep	0.681 0.004	1																			
P-Ang	0.739 0.001	0.845 <0.001	1																		
P-Vig	-0.24 0.361	-0.01 0.949	0.179 0.508	1																	
P-Fat	0.725 0.001	0.859 <0.001	0.751 0.001	-0.238 0.376	1																
P-Con	0.691 0.003	0.866 <0.001	0.773 <0.001	-0.155 0.565	0.880 <0.001	1															
P-TM	0.838 <0.001	0.938 <0.001	0.873 <0.001	-0.220 0.413	0.931 <0.001	0.918 <0.001	1														
H-N0	0.456 0.076	0.604 0.013	0.421 0.104	-0.472 0.065	0.737 0.001	0.616 0.011	0.673 0.004	1													
H-N25	0.431 0.096	0.163 0.547	0.123 0.651	-0.580 0.028	0.493 0.052	0.495 0.051	0.397 0.128	0.559 0.025	1												
H-N45	0.278 0.298	-0.17 0.508	-0.01 0.949	-0.548 0.028	0.132 0.625	0.121 0.656	0.103 0.703	0.346 0.189	0.752 0.001	1											
PA-N0	-0.10 0.702	0.226 0.400	0.113 0.677	0.489 0.055	-0.045 0.869	-0.019 0.945	0.003 0.992	-0.055 0.840	-0.475 0.063	-0.639 0.008	1										
PA-N25	-0.04 0.859	-0.04 0.869	-0.136 0.615	0.309 0.244	-0.256 0.339	-0.162 0.549	-0.175 0.517	-0.243 0.364	-0.412 0.113	-0.357 0.175	0.634 0.008	1									
PA-45	0.043 0.874	-0.09 0.723	-0.085 0.756	0.386 0.139	-0.187 0.489	-0.204 0.449	-0.173 0.522	-0.323 0.223	-0.219 0.415	-0.140 0.605	0.456 0.076	0.811 <0.001	1								
RSA-N0	0.431 0.095	0.348 0.187	0.343 0.193	-0.026 0.924	0.361 0.169	0.264 0.324	0.376 0.151	0.218 0.417	-0.054 0.842	0.148 0.584	0.325 0.220	0.409 0.116	0.458 0.075	1							
RSA-N25	0.486 0.057	0.487 0.056	0.345 0.191	-0.472 0.065	0.536 0.032	0.387 0.138	0.553 0.026	0.566 0.022	0.269 0.313	0.272 0.309	0.196 0.466	0.080 0.769	0.141 0.602	0.720 0.002	1						
RSA-N45	0.517 0.040	0.526 0.036	0.393 0.132	-0.288 0.279	0.542 0.030	0.340 0.197	0.548 0.028	0.450 0.081	0.042 0.876	0.055 0.839	0.263 0.324	0.118 0.662	0.170 0.530	0.792 <0.001	0.918 <0.001	1					
RPE-N0	-0.05 0.852	0.090 0.741	-0.177 0.512	-0.134 0.620	0.105 0.699	0.076 0.781	0.024 0.928	0.186 0.489	-0.057 0.834	-0.05 0.843	-0.347 0.188	0.013 0.962	-0.06 0.816	0.014 0.958	-0.13 0.623	0.000 0.999	1				
RPE-N25	-0.18 0.484	-0.00 0.982	-0.181 0.502	0.286 0.283	-0.139 0.607	0.009 0.972	-0.148 0.583	-0.078 0.774	-0.187 0.489	-0.260 0.330	-0.003 0.993	0.479 0.060	0.335 0.204	-0.15 0.557	-0.442 0.086	-0.38 0.143	0.699 0.003	1			
RPE-N45	0.112 0.681	0.281 0.292	-0.053 0.846	0.009 0.972	0.196 0.466	0.316 0.234	0.172 0.523	0.082 0.763	0.025 0.926	-0.218 0.417	-0.075 0.783	0.327 0.217	0.156 0.565	0.007 0.981	-0.159 0.557	-0.05 0.840	0.728 0.001	0.791 <0.001	1		
VAS-N25	-0.15 0.557	-0.20 0.454	-0.116 0.670	0.528 0.035	-0.403 0.122	-0.448 0.082	-0.339 0.198	-0.387 0.139	-0.677 0.004	-0.304 0.252	0.303 0.253	0.442 0.086	0.360 0.171	0.278 0.297	-0.16 0.533	0.017 0.949	0.115 0.671	0.234 0.384	0.116 0.669	1	
VAS-N45	-0.09 0.742	0.250 0.350	-0.028 0.917	0.184 0.496	-0.026 0.923	0.060 0.826	0.039 0.885	-0.084 0.758	-0.523 0.038	-0.708 0.002	0.420 0.106	0.519 0.039	0.105 0.698	−0.0 0.888	-0.17 0.526	-0.06 0.817	0.302 0.256	0.510 0.044	**0.564** 0.023	0.320 0.227	1

Table 6. Exploratory correlations between PSQI, POMS dimensions, and performance variables across nap conditions. P-Ten: Profile of Mood States tension, P-Dep: Profile of Mood States depression, P-Ang: Profile of Mood States anger, P-Vig: Profile of Mood States vigor, P-Fat: Profile of Mood States fatigue, P-Con: Profile of Mood States confusion, P-TM: Profile of Mood States total mood, H: Hooper Index, PA: Pro Agility Test, RSA: Repeated-Sprint Ability Test, RPE: Rate of Perceived Exertion, VAS: Visual Analogue Scale, N0: No nap, N25: 25 min nap, N45: 45 min nap. These correlations are presented for descriptive purposes and were not used for primary hypothesis testing.

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reliably captured sleep onset, nap duration, and wake times; however, wearable devices have limited accuracy in differentiating specific sleep stages and therefore mechanistic interpretations related to sleep architecture should be considered with caution. The sample consisted exclusively of trained male participants with intermediate chronotypes and no habitual daytime napping routine, which limits the generalizability of the findings to female athletes, habitual nappers, or individuals with different chronotype profiles. In addition, the modest sample size may have reduced the statistical power to detect subtle differences in repeated-sprint ability, and RSA-related findings should be interpreted cautiously. Finally, outcomes were assessed only in the short term and several measures relied on subjective self-report, which may introduce bias compared to objective physiological markers. Future studies should include larger and more diverse samples, objective sleep staging methods, and longer intervention periods.

Conclusion

This study demonstrated that a 45-min strategic nap enhanced agility performance and reduced perceived exertion in adolescent athletes, supporting its role as an effective recovery strategy. While repeated-sprint ability outcomes did not show consistent condition effects, post-hoc analyses indicated faster best sprint times after the 45-min nap compared to the 25-min nap, alongside greater fatigue accumulation across repeated efforts. These findings suggest that nap duration may differentially influence motor performance, fatigue resistance, and perceptual responses. Coaches and practitioners should therefore consider both the potential benefits and drawbacks of longer naps when integrating napping strategies into training and competition schedules. From an applied perspective, these findings indicate that both short and slightly longer daytime naps can be strategically used by adolescent soccer players, with nap duration tailored to the specific performance demands and scheduling constraints.

Future research should explore the role of chronotype variability in modulating nap-related performance outcomes by including diverse circadian profiles of participants. The inclusion of female athletes and more ecologically valid field-based protocols would improve the generalizability of the findings. Longitudinal studies are needed to assess the sustained efficacy of strategic napping on training adaptation and performance. Furthermore, the integration of neurophysiological assessments, such as functional magnetic resonance imaging (fMRI), may uncover underlying mechanisms and contribute to a deeper understanding of the cognitive and neural correlates of sleep-based interventions in sports performance contexts.

Data availability

Data are available for research purposes from the corresponding author upon reasonable requests.

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Author contributions

Conceptualization; M.Ö, Ö.E, and M.I.A; data curation, M.Ö, Ö.E,; formal analysis, M.Ö, Ö.E, and M.I.A; methodology, M.Ö, Ö.E, and M.I.A; writing—original draft M.Ö, Ö.E, and M.I.A, writing—review and editing, M.Ö, Ö.E, and M.I.A. All authors have read and agreed to the published version of this manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

Ethical approval was granted by the Non-Interventional Research Ethics Committee of Inonu University. Written Informed consent was obtained from each participant in accordance with the Declaration of Helsinki.

Additional information

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