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JUTARNJE I VEČERNJE VARIJACIJE U TESTIRANJU TJELESNE SPREMNOSTI OSNOVNOŠKOLSKE DJECE

MORNING TO EVENING VARIATIONS IN PHYSICAL FITNESS TESTING

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ABSTRACT

Testing physical fitness in children is essential for monitoring their physical development. The goal of this study was to determine whether there are variations in physical fitness test results throughout the day among primary school-aged children.

A total of 60 primary school children (26 girls and 34 boys), aged 10 to 12, voluntarily participated in this study. All participants completed selected physical fitness assessments targeting cardiorespiratory fitness (CRF), strength, flexibility, and agility in two separate testing sessions—one in the morning (8:00–9:30 a.m.) and another in the evening (6:00–7:30 p.m.).

Significant statistical differences ($p < 0.01$) were observed in the test standing long jump when comparing morning and evening results. Similarly, differences were found in the 20-meter shuttle run test in total distance covered ($p < 0.01$). No other differences in physical fitness test results were observed between morning and evening sessions. Conclusions:

It can be concluded that power and CRF demonstrated diurnal variation in primary school-aged children.

Key words: motor abilities testing, adolescents, diurnal variations

SAŽETAK

Testiranje tjelesne spremnosti kod djece ključno je za praćenje njihovog tjelesnog razvoja. Cilj ove studije bio je utvrditi postoje li tijekom dana varijacije u testovima tjelesne spremnosti među djecom osnovno-školske dobi.

U ovom istraživanju je dobrovoljno sudjelovalo ukupno 60 djece (26 djevojčica i 34 dječaka) osnovnoškolske dobi, između 10 i 12 godina. Svi sudionici su proveli odabrane testove za procjenu tjelesne spremnosti za kardiorespiratornu kondiciju (CRF), snagu, fleksibilnost i agilnost u dvije odvojene sesije testiranja – tijekom jutra (8:00-9:30 h) i navečer (18:00-19:30 h). Uočene su značajne statistički razlike ($p < 0{,}01$) u testu skok u dalj s mjesta pri usporedbi jutarnjih i večernjih rezultata. Slično tome, postoji razlika u shuttle run testu na 20 m, kako u ukupnim pre**đenim** metrima ($p < 0{,}01$).

Nije bilo drugih razlika u testovima tjelesne spremnosti između jutarnjeg i večernjeg testiranja. Može se zaključiti da su eksplozivna snaga i CRF varirali tijekom dana kod djece osnovnoškolske dobi.

Ključne riječi: motoričke sposobnosti, adolescenti, dnevne varijacije

INTRODUCTION

Physical fitness is crucial in primary school children as it lays the foundation for a healthy lifestyle and overall well-being [20]. Higher levels of physical fitness are associated with improved cardiovascular health, better metabolic profiles, and enhanced cognitive performance during childhood, while also reducing the risk of developing chronic diseases like obesity, diabetes, and cardiovascular conditions later in life [24]; [21]. Additionally, fitter and physically active children are more likely to maintain active lifestyles into adulthood, supporting long-term health and quality of life [2]. These findings underscore the importance of promoting physical fitness early in life to establish a foundation for lifelong health and resilience.

Fitness testing among primary school children is essential for assessing their physical development and identifying areas that require improvement to support overall health [25]. Physical fitness testing in schools typically includes assessments of cardiorespiratory fitness, muscular strength, flexibility, and body composition [7]. These tests can help in tracking children's growth and fitness levels, potentially guiding interventions to enhance physical activity and overall health.

One area of interest is the potential for daily variations in fitness test results. Factors such as sleep quality, nutrition, daily physical activity, mood, and even weather conditions can influence a child's performance on any given day. For example, children who have had more sleep or a nutritious breakfast may perform better in physical activities compared to those who haven't [14]. Additionally, motivation levels and psychological factors like stress or excitement about the test can also play significant roles [29]

Variations in fitness testing among primary school children is influenced by several factors, as highlighted in several studies. Augste and Künzell [3] found that physical fitness levels in elementary school children exhibit significant seasonal variations, with higher fitness levels typically observed in the warmer months. This suggests that outdoor activities during these periods may contribute to better performance in fitness tests. Similarly, Teich, Golle, and Kliegl [28] reported that the timing of fitness assessments within the school year affects the results, with children performing differently at the beginning and end of the academic year due to changes in physical activity levels, curriculum demands, and seasonal influences. Additionally, Yang et al. [30] examined the relationship between health-related fitness and physical activity during weekdays, finding that students with higher fitness levels tend to engage in more physical activity after school, indicating that habitual activity patterns can influence daily fitness test outcomes. Regarding daily variations in fitness levels among school children, it was that they are influenced by circadian rhythms, with performance fluctuating throughout the day [9]; [27]. Studies suggest that children may exhibit higher levels of physical fitness, including strength and endurance, in the afternoon or evening, when their body temperature is higher and muscles are more flexible [15]. Specifically, Souissi et al. (2010) [27] observed that children perform better in physical fitness during the afternoon compared to the morning assessment. These studies collectively underscore the importance of considering temporal factors when assessing the physical fitness of primary school children to ensure accurate and meaningful evaluations.

Understanding these daily variations is important for accurately assessing a child's fitness level. If significant daily fluctuations are found, it may suggest the need for multiple testing sessions to obtain a reliable average performance. This knowledge can also help educators and policymakers design better fitness programs that accommodate these variations, ensuring that every child has the opportunity to demonstrate their true fitness potential.

Therefore, the aim of this study was to determine if there are daily variations in physical fitness testing among primary school children. Studying daily variations in fitness testing among primary school children can provide deeper insights into the factors that influence physical performance and help improve the accuracy and effectiveness of fitness assessments and related health interventions.

MATERIALS AND METHODS

Participants

A total of 60 (26 girls) primary school children aged 10-12 voluntarily participated in this study. Prior to the enrolment in the study, parents reported their child's health history and current activity status through a questionnaire and only healthy, children from 10 to 12 years old were chosen. All the children had the same two classes of physical education per week and were not involved in additional organized training during this study. Participants were excluded if they had a chronic disease or had an osteomuscular condition that would limit their ability to perform exercises. The study was approved by the Research Ethics Committee of the Faculty of Sport and Physical Education in Niš (No. 04-428/2 approved 23. 03. 2024), and written informed consent was obtained from both parents and children.

Procedures

Testing was completed during October, one month after the beginning of school year. Prior to physical fitness testing, sleep quality and quantity during the previous night were obtained using the standardized questionnaire. The questionnaire consisted of questions related to perceived sleep quality scored on a 10-point Likert scale with 1 representing poor and 10 representing excellent sleep quality. Participants also provided estimation of sleep duration (hh:mm) from the previous night including the latency period. Morning and evening heart rates were measured before physical fitness testing in the non-dominant arm. Prior to physical fitness testing, participants completed a standardised warm-up consisting of moderate intensity jogging (8 min), static stretching (5 min), and brief bouts of high-intensity running (2 min).

All participants completed physical fitness tests for cardiorespiratory fitness, strength, flexibility and agility in two separate testing sessions in the morning (8:00-9:30 h) and in the evening (18:00-19:30 h). Time of the morning and evening testing sessions was similar to previous studies [17-18]. Participants were informed to avoid any type of exercise as well as afternoon napping or sleeping between morning and evening testing sessions and to continue with their usual lifestyle activities. All testing was carried out in similar environmental conditions (20-25˚C) on the same court in an indoor facility in the same order.

Cardiorespiratory fitness was assessed using the original 20 m shuttle run test: The 20 m SRT. Briefly, participants had to run back and forth between two lines 20 m apart with an audio signal. The test if finished if the children could not reach the end lines in time with the audio signal on two consecutive tries or if they stopped because of exhaustion. The initial speed was 8.5 km/h and rising through levels. The test results were expressed in meters because it provides a more precise and interpretable measure of children's performance and fitness level [19].

Upper-limb muscular strength was assessed with the handgrip strength test [26]. The test required squeezing with maximum effort for 2–3 seconds using the analogue TKK dynamometer (TKK 5001, Grip-A, Takei, Tokyo). The elbow had to stay extended, and only the hand could touch the dynamometer. Children performed two nonconsecutive attempts with each hand. The best value of the two trials for each hand was chosen (kg).

The power of the lower limbs was measured with standing long jump. Participants were instructed to jump as far as possible and land with their feet together and in an upright position [6]. The distance was recorded in centimeters from the starting line to the heel of the participant. Initially, two familiarization jumps were performed, then participants had three attempts, with the best jump selected for analysis.

Muscular endurance was assessed with Sit-Ups 30 sec. The task was to perform as many complete sit-ups as possible in a 30 s time frame [1]. The participants were required to lie on their back with bent knees and hands clasped behind the head. From this position, they had to quickly rise to a seated position and return to the starting position. The number of correctly performed sit-ups in 30 seconds was recorded.

The 4x10-meter shuttle run test assesses agility in children. It is conducted on a flat, non-slip surface with two markers or cones placed exactly 10 meters apart. The child starts behind one marker, and on the signal "Go," runs to the opposite cone, touches it with their hand, and returns to the starting point, repeating this sequence four times for a total distance of 40 meters. Participants must touch the line or cone at each turn, and any missed touches require a repeat trial. The time to complete the test is recorded using a stopwatch. The result is the total time, recorded in seconds to the nearest 0.1s. The best out of three attempts was taken for further analysis.

Flexibility of the lower back and hamstring muscles was assessed by the sit-and-reach test from EUROFIT test battery. In this test, the participant sits on the floor without shoes, legs extended straight in front. With palms facing down and hands stacked, the children must reach forward along the measuring line as far as possible, holding the position for one to two seconds while the distance is measured. The best of three attempts was recorded (cm).

Each child was assessed individually of all tests in a school setting by the same trained evaluators using standardized equipment.

Statistical analysis

All data are presented as means ± standard deviation. Since normality of data distribution was confirmed by the Kolmogorov– Smirnov test, any systematic daily changes in physical fitness testing performance were assessed using paired sample T test. Additionally, effect size [17] was evaluated using Cohen's d (standardized mean differences with a 95% confidence interval). Based on Cohen's guidelines, the effect size is considered small (~0.2), medium (~0.5), or large (~0.8). Moreover, the agreement between morning and evening measurement was also assessed according to the method of Bland & Altman. The analysis measures bias as estimated from mean differences, the 95% confidence interval for bias, and the limits of agreement. All statistical analyses were performed using SPSS 24.0 software (SPSS Inc., Chicago, IL). The alpha level was set at < 0.05 to indicate statistical significance.

RESULTS

The basic descriptive characteristics of the participants, including age, height, body mass, and body mass index (BMI), are presented in Table 1.

Means ± standard deviation for each performance test measured in the morning and evening are shown in Table 2. Significant differences ($p < 0.01$) in standing long jump were observed in comparing the morning and evening performance. Similarly, but in favor of evening testing there were significant differences for shuttle run test 20m ($p=0.01$) (Table 2). There were no other differences in physical fitness tests between morning and evening testing (Table1). Additionally, analyzing standardized differences, better cardiorespiratory fitness with moderate increase (Cohen's d = 0.54) meters was seen in the evening.

Mean differences for the assessed fitness tests were within the limits of Bland and Altman, with most data

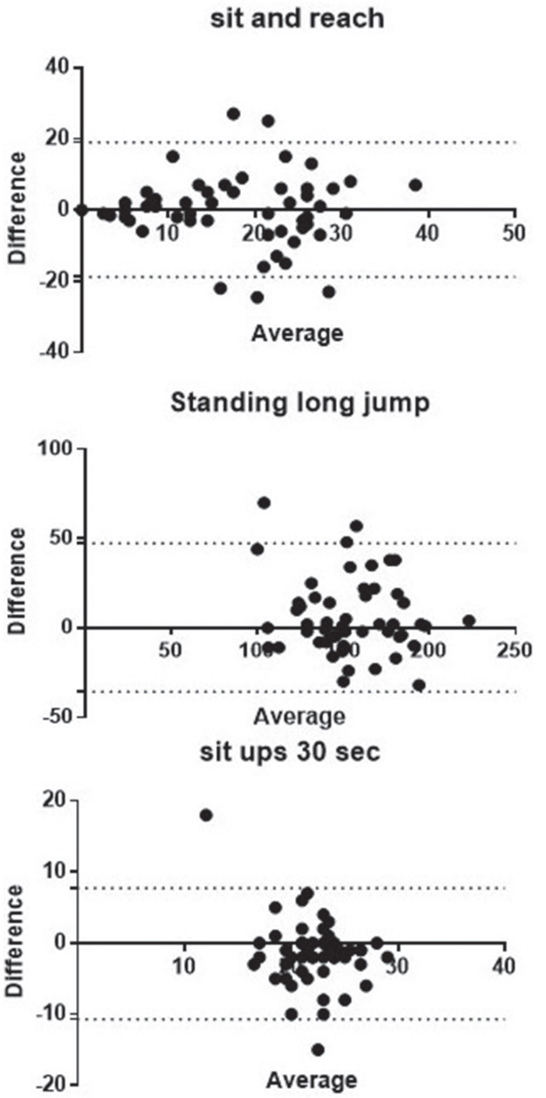

Figure 1. Agreement between morning and evening testing for sit and reach, standing long jump and sit ups for 30 seconds

Slika 1. Podudarnost između jutarnjeg i večernjeg testiranja za pretklon u sjedu, skok u dalj s mjesta i trbušnjake u trajanju od 30 sekundi.

Table 1. Descriptive characteristics of children

Tablica 1. Opisne karakteristike djece

	Age (years)	Height (cm)	Body mass (kg)	BMI (kg/m^2)
Boys (n=34)	11.4±0.8	146.7±7.3	42.6±10.5	19.6±3.8
Girls (n=26)	11.5±0.7	147.5±7.2	42.5±10.4	19.4±3.8

n - number of children, BMI - body mass index

points falling within the limits of agreement for bias (Figure 1 and 2). For the sit and reach test, the mean difference was 0.1±10 cm, with limits of agreement spanning from -19 to 19 cm. For standing long jump, the mean difference was 6±21 cm, with limits of agreement ranging from -36 to 47 cm. The sit-ups test revealed a mean difference of -1±5 repetitions, with limits of agreement between -11 to 8 repetitions.

Mean difference for 4x10m agility test was 0.1±2 sec, respectively, with limits of agreement of -3 to 4 sec. Similarly, handgrip strength for the dominant and non-dominant hands showed mean differences of -0.4±6 kg and -0.2±5 kg, respectively, with limits of agreement of -12 to 11 kg for the dominant hand and -11 to 10 kg for the non-dominant hand. Finally, for the shuttle run (20 meters), the mean difference in meters was -133±343 meters, with limits of agreement from -805 to 539 meters.

DISCUSSION

This study investigated daily variations in physical fitness test performance among primary school children. We found biggest differences in power between morning and evening testing. Children showed that standing long jump was much better in the morning compared to evening. On the contrary, there were differences in 20m shuttle run test but in favor of evening testing.

Table 2. Physical fitness test results in the morning and evening

Tablica 2. Rezultati testova tjelesne spremnosti ujutro i navečer

	Morning (Mean ±SD)	Evening (Mean ±SD)	p value	Effect size C' d (CI)	
sit and reach (cm)	23.18±7.57	23.98±7.94	0.74	0.10 (-0.25 0.46)	*trivial*
Standing long jump (cm)	154.29±31.09	138.71±28.93	0.01	-0.52 (-0.88 -0.16)	*moderate decrease*
Sit ups 30 sec (times)	20.28±4.06	22.34±5.22	0.11	0.44 (0.08 0.80)	*small increase*
4x10m (s)	14.83±1.89	15.15±2.01	0.45	0.16 (-0.19 0.52)	*trivial*
grip strength D (kg)	25.16±6.77	24.74±6.58	0.74	-0.06 (-0.42 0.30)	*trivial*
grip strength ND (kg)	22.29±6.13	21.90±6.61	0.75	-0.06 (-0.42 0.30)	*trivial*
shuttle run 20m (m)	548±232.62	689.33±282.433	0.01	0.54 (0.18 0.91)	*moderate increase*

< 0.05 indicate statistical significance; D dominant; ND non dominant; C' d Cohen's d

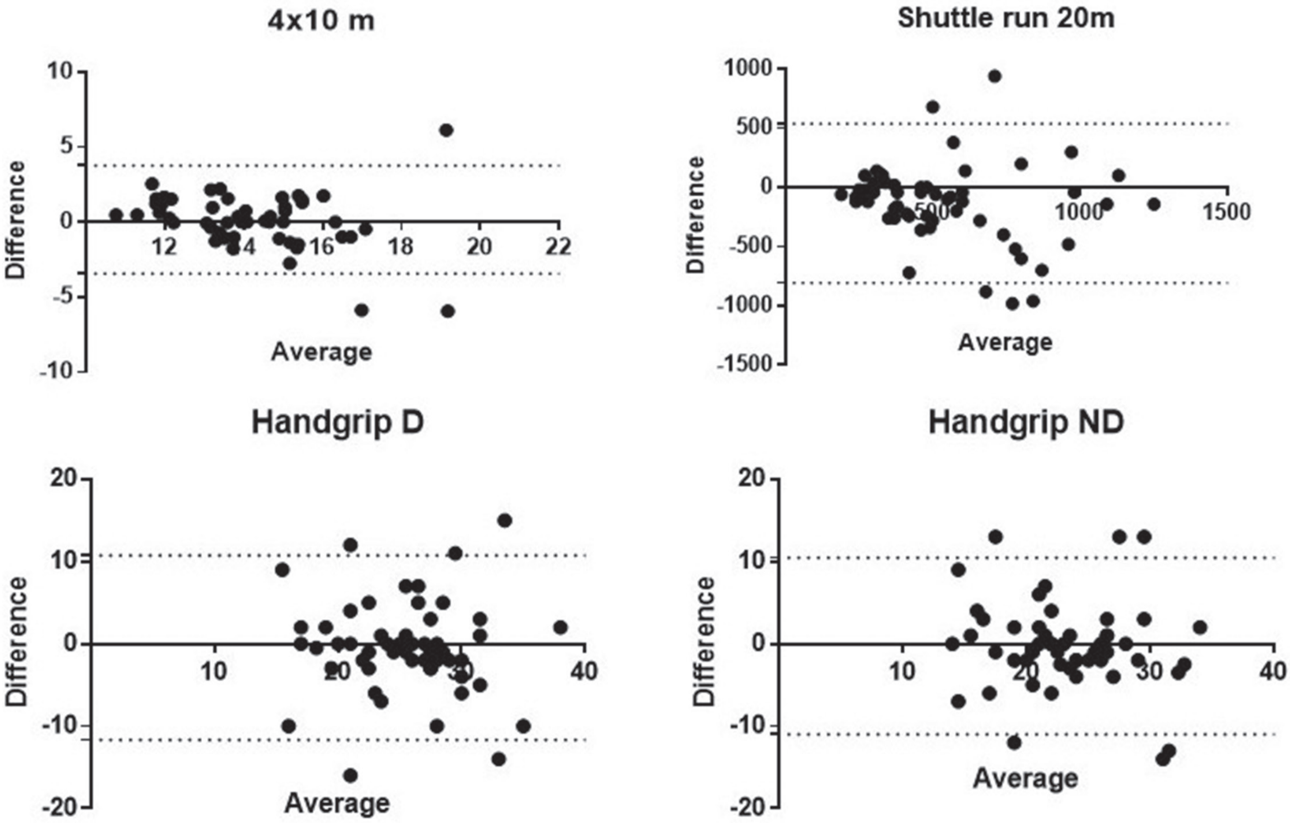

Figure 2. Agreement between morning and evening testing for 4x10m, handgrip D and ND and shuttle run 20m
Slika 2. Podudarnost između jutarnjeg i večernjeg testiranja za 4x10 m, stisak šake D i ND te shuttle run na 20 m.

Fitness testing in children is vital for monitoring their physical development, identifying potential health issues early, and tailoring interventions to promote lifelong healthy habits [20]. It provides valuable data for educators and health professionals to track progress, set realistic goals, and adapt physical education programs to meet individual needs. Moreover, fitness testing can help instill a sense of achievement and motivate children to stay active.

Daily variations in performance, such as those from morning to evening, are significant when conducting fitness assessments. Studies have shown that children's physical performance can fluctuate throughout the day due to factors like circadian rhythms, energy levels, and daily routines [18]. Morning assessments may reflect a child's natural baseline fitness, as physical performance in the early hours is less influenced by prior physical activity or fatigue accumulated during the day [8]. In contrast, afternoon or evening tests might capture the effects of daily physical activity and accumulated fatigue, leading to variations in motor coordination, strength, and overall performance [9]. Recognizing these variations is essential for interpreting fitness test results accurately and ensuring that assessments are fair and representative of a child's true physical capabilities [22]. Additionally, understanding circadian influences on performance can guide the scheduling of physical activities and tests at times when children are likely to perform their best [11].

The highest magnitude of change in fitness testing was observed for standing long jump. There are several possible reasons why children might perform better in the standing long jump test in the morning compared to the evening. In the morning, children are typically more rested and have higher energy levels after a night's sleep. As the day progresses, physical and mental fatigue from daily activities can decrease performance [22]. Moreover, cognitive functions, including focus and coordination, are generally sharper in the morning [10]. Better cognitive function can enhance motor skills and overall performance in physical tasks like the standing long jump [4]. While body temperature tends to be higher later in the day, which can improve muscle flexibility and performance in some activities [23], the initial boost of cortisol in the morning can enhance alertness and physical performance temporarily [12]. Morning assessments might benefit from a more structured and predictable routine, leading to less anxiety and better performance [8]. As the day goes on, variations in mood and stress from daily activities can negatively impact performance [11]. Daily activities, including schoolwork and physical play, can lead to cumulative physical fatigue by the evening, reducing the ability to perform high-intensity activities such as the standing long jump [27].

Research on diurnal variations in physical performance has demonstrated that power output and other physical capacities fluctuate throughout the day due to circadian rhythms, which regulate physiological and metabolic functions [5]. Studies have consistently shown higher power output and reactive strength later in the day, coinciding with peak body temperature and neuromuscular efficiency [8-9] . In children, short-term performance measures, such as those assessing power, also exhibit time-of-day effects, with better results observed in the afternoon compared to the morning, likely due to enhanced muscle flexibility and coordination later in the day [27]. These findings are supported by evidence that circadian rhythms influence performance reliability across various time points [11]. While morning assessments might benefit from consistency in routine and less accumulated fatigue, the variations in power observed later in the day highlight the importance of considering the timing of tests to ensure validity and fairness in evaluating children's physical performance [22]. Thus, recognizing diurnal influences and ensuring standardized test timing are critical for reliable assessments in research and practice.

In contrast to standing long jump, this study found that results for cardiorespiratory fitness were better in the evening. Research indicates that children's cardiorespiratory performance can fluctuate depending on the time of day, with performance often peaking in the afternoon or early evening. This pattern is believed to be driven by circadian rhythms, which regulate body temperature, hormone levels, and energy metabolism throughout the day [11]. For example, Souissi et al. [27] observed that 10- to 11-year-old boys performed better in aerobic endurance tasks during the afternoon compared to the morning. Furthermore, Mhenni et al. [16] demonstrated that maximal physical performances in team handball players were better in the evening compared to the morning, which can be extrapolated to suggest similar patterns in cardiorespiratory fitness. Yang et al. [30] explored daily variations by examining the relationship between health-related fitness and physical activity during weekdays. Their study revealed that children with higher fitness levels tend to engage in more physical activity after school, which can positively reinforce their fitness levels. However, daily performance can vary based on factors such as time of day. Children might exhibit better performance in the morning due to higher energy levels and cognitive freshness, while fatigue from daily activities can lead to poorer performance in the evening. This diurnal variation suggests that the timing of fitness tests within a day can influence the results, with morning assessments potentially yielding better performance metrics. It is well documented that children's cardiorespiratory fitness, specifically VO_2 max (maximal oxygen consumption), can fluctuate based on the time of day, with potential influences from sleep, diet, and prior activity levels [15]. However, it is also crucial to consider how VO_2 max is measured, as different protocols or testing conditions can yield varying results [13]. The reliability and validity of VO_2 max tests depend on the accuracy of the equipment used (e.g., metabolic carts) and the testing procedure (e.g., ramp protocols or steady-state tests), which can influence the outcomes and interpretation of fitness levels [13].

The findings from the current study highlight and confirm the importance of considering daily variations when conducting fitness tests among primary school children. To ensure accurate and meaningful evaluations, educators and health professionals should conduct fitness tests at different times of the year and at different times of the day to account for both seasonal and daily variations, try to maintain consistent testing conditions, such as similar weather conditions and times of day, to reduce variability and also acknowledge and adjust for factors such as recent physical activity, sleep quality, nutritional status, and psychological state, which can all impact performance.

Despite interesting outcomes in this study, some important limitations should be acknowledged. First, sample size was low for such important school settings studies. Second, the nutritional status of children was not controlled prior to morning and evening testing. Third, we should compare more types of jumps having in mind that this was horizontal jump. Moreover, children's motivation and effort levels can vary greatly and are difficult to quantify, potentially affecting performance outcomes.

CONCLUSIONS

Power performance such as standing long jump performance varied across the day, with superior performance observed in the morning compared to the evening in primary school children. On the contrary, CRF appear to be significantly better in the evening compared to morning testing. By adopting a comprehensive and flexible approach to fitness testing, schools can obtain a more reliable assessment of children's physical fitness, better identify areas needing improvement, and design interventions that promote consistent physical activity throughout the year.

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