

The 24-Hour Movement Guidelines Adherence and its Effect on Physical Fitness in Children from the Republic of North Macedonia

Adherencia a las Directrices de Actividad Física de 24 Horas y su Efecto en la Aptitud Física de Niños de la República de Macedonia del Norte

Armend Kastrati¹; Nazrije Gashi¹; Seryozha Gontarev² & Georgi Georgiev²

KASTRATI, A.; GASHI, N.; GONTAREV, S. & GEORGIEV, G. The 24-Hour movement guidelines adherence and its effect on physical fitness in children from the Republic of North Macedonia. *Int. J. Morphol.*, 44(4):1114-1121, 2026.

SUMMARY: The aim of this study was to determine the association between adherence to 24-hour movement guidelines and different components of physical fitness in children aged 9 to 11 years in the Republic of North Macedonia. The study included 414 respondents, whose fitness components were assessed through a standardized battery of tests (cardiorespiratory fitness, muscular strength, endurance, flexibility, coordination, agility and speed), and data on physical activity, screen time and sleep duration were collected through a standardized questionnaire. The analysis was performed using linear regression controlling the age, sex and BMI. The results showed that only 8.45 % of respondents met all three recommendations. Adherence to the recommendations for moderate to vigorous physical activity was the most consistent predictor of better results in all components of physical fitness. Combined adherence to all three guidelines was associated with better values of cardiorespiratory endurance, motor fitness and general physical fitness, suggesting a possible synergistic effect. Screen time and sleep duration had limited, selective effects. The research highlights the benefits of an integrated approach that includes all aspects of 24-hour movement to promote physical health in children. At the same time, it identifies the need for interventions and future longitudinal studies with objective measures aiming further understanding of these relationships.

KEY WORDS: Physical fitness; Children; Physical activity; Sleep; Screen time; 24-hour movement guidelines.

INTRODUCTION

Physical fitness is a multidimensional biopsychosocial concept that reflects an individual's capacity to perform effectively daily and sports activities without extreme fatigue, with sufficient reserve potential to cope with stress and emergency situations (Caspersen *et al.*, 1985). It is a recognized indicator of overall health and vitality, especially in the pediatric population, where it serves as a predictor of long-term physical, mental, and cognitive well-being (Ortega *et al.*, 2008; García-Hermoso *et al.*, 2019, 2022).

Health-related physical fitness is based on several key components, cardiorespiratory capacity, muscular strength and endurance, motor competence (speed, agility, coordination), and flexibility, all of which are closely linked to metabolic, cardiovascular, and mental health (Utesch *et al.*, 2019; Cadenas-Sanchez *et al.*, 2021). Research shows that higher levels of fitness are associated with better body composition, favorable lipid profiles, lower risk of obesity

and chronic diseases, higher academic performance, and improved brain structures (Álvarez-Bueno *et al.*, 2020).

In the last decade, the modern approach to promoting children's health has shifted towards a 24-hour movement model, which includes not only physical activity, but also time spent in sedentary activities (e.g., recreational screen time) and sleep duration (Tremblay *et al.*, 2016). This holistic concept assumes that a balanced integration of these three components is necessary for the optimal development of physical and psychofunctional capacities in children. Despite growing support from the scientific community, low compliance with all three directions has been recorded in real populations, which makes it difficult to interpret their cumulative effect on health outcomes (Zhao *et al.*, 2024).

Taking into consideration the lack of research that simultaneously analyzes physical activity, screen time, and

¹University of Pristina "Hasan Prishtina", Prishtina, Republic of Kosovo.

²Faculty of Physical Education, Sport, and Health, Ss. Cyril and Methodius University, Skopje, Republic of North Macedonia.

sleep in relation to multiple fitness components, there is a need to expand the scientific database with data from local contexts. In this regard, this study aims to assess the association between the 24-hour movement guidelines adherence and its effect on physical fitness components in children aged 9 to 11 years in the Republic of North Macedonia.

The main hypothesis of the study is that simultaneous adherence to all three 24-hour recommendations (moderate to vigorous physical activity ≥ 60 minutes per day, screen time ≤ 2 hours per day, and 9 to 11 hours of sleep) is statistically significantly associated with higher levels of cardiorespiratory endurance, muscular strength, trunk strength endurance, flexibility, speed, agility, and general physical fitness in children.

MATERIAL AND METHOD

A sample of respondents

The research was conducted on a sample of 414 respondents, randomly selected from several primary schools in the Skopje region, Republic of North Macedonia. The respondents were 9 to 11 years of age, which included students from the second educational period. The sample was structured into two subgroups according to sex: 205 male and 209 female respondents. The study included students whose parents or guardians provided written permission to participate. In addition, inclusion criteria were the students' psychophysical health and regular attendance at Physical and health education classes.

Students and parents were informed in detail about the voluntary and anonymous nature of their participation, which ensured full respect for ethical principles. The research was conducted in accordance with the provisions of the Helsinki Declaration of 1961 (Edinburgh revision, 2013), with special emphasis on the protection of the rights and dignity of the respondents

Sample variables

Physical fitness was assessed using a system of standardized fitness tests with proven validity and reliability in children and adolescents. Cardiorespiratory endurance was assessed using the 20 m shuttle-run test, and $VO_2\text{max}$ was calculated using the formula of Nevill *et al.* (2021). Lower limb strength was assessed using the standing long jump test, while upper limb strength was assessed using the handgrip dynamometry test. Muscular endurance of the trunk was assessed using a 30-second sit-ups test. Flexibility was assessed using the sit-and-reach test, while speed, agility, and coordination were assessed using the 4×10m shuttle run

test, with the values inverted for consistent interpretation. Composite indexes were calculated for additional analysis: muscular fitness (average of z-scores from strength assessment tests) and total fitness (average of z-scores for all fitness tests). Measurements were performed in standardized school settings, by trained individuals, using protocols from the EUROFIT, ALPHA, and MAKFIT studies. (Ruiz *et al.*, 2011; Gontarev *et al.*, 2018).

Data on physical activity were collected using a validated questionnaire based on the instruments of the international initiative Health Behaviour in School-Aged Children (HBSC), adapted within the framework of the national MAKFIT system (Gontarev *et al.*, 2018). The questionnaires were completed by the parents/guardians of the respondents, in order to ensure greater accuracy and representativeness of the data on the daily habits of the children. Two aspects of physical activity were included: organized activity (participation in sports clubs or training) and unstructured activity (play and movement in leisure time). Parents also reported the average duration of these activities per day during a week, which allowed the calculation of the average daily time spent in physical activity.

In addition, data were collected on screen time (TV, computer, mobile phone or console use) and nightly sleep duration, with separate questions for workdays and non-working days. Based on these data, each respondent was classified according to the Canadian 24-Hour Movement Guidelines, according to whether they met or did not meet the following recommendations: a minimum of 60 minutes of daily moderate-to-vigorous physical activity, ≤ 2 hours of screen time, and 9–11 hours of nightly sleep.

Additionally, several individual characteristics that may act as confounding factors (covariates) were taken into account in the statistical analysis, including age (expressed in years with decimals), sex (girls/boys), and body mass index (BMI), calculated as the ratio of body mass to the square of body height. The classification of nutritional status (underweight, normal weight, and overweight/obese) was determined according to the international criteria of the International Obesity Task Force (IOTF). These covariates were included in all regression models in order to control for their influence on the outcome measures and to ensure greater analytical precision and interpretative validity of the results.

Statistical analysis

The data were processed using descriptive and inferential statistics. For the ratio scale variables, arithmetic mean and standard deviation were calculated, and the normality of the distribution was checked with the

Kolmogorov-Smirnov test. For the categorical variables, frequencies and percentages were calculated, and the respondents were grouped into eight categories according to the degree of fulfillment of the 24-hour recommendations (do not meet the guidelines, meet only the physical activity recommendations, meet only the screen time recommendations, meet only the sleep duration recommendations, meet physical activity + screen time, meet physical activity + sleep duration, meet screen time + sleep duration, and meet *all* three recommendations).

The main analysis was based on linear regression, with nominal predictors (compliance with 24-hour recommendations) treated as dummy codes. This approach allowed for comparison of each compliance category (e.g. physical activity only, sleep only, all three recommendations, etc.) with the reference group (those who did not comply with any recommendation), with the effect of each group on the continuous dependent variables (components of physical fitness) being expressed as the difference in mean values. This allowed for the assessment of specific associations between different patterns of adherence to recommendations and levels of physical fitness. The models were controlled for age, sex and BMI as covariates, in order to reduce the influence of potential confounders. Statistical analysis was performed with SPSS (v.26.0), with a significance level set at $p < 0.05$.

RESULTS

The basic descriptive statistics of the respondents are shown in Table I. From the review of it can be seen that the average age of the respondents is 9.70 ± 0.70 years, with an average body height of 142.16 ± 8.27 cm and a body mass of 40.28 ± 10.73 kg. The average value of the body mass index (BMI) is 19.73 ± 3.81 kg/m², which is within the expected range for this age group. According to the BMI categories, the majority of the respondents (52.0 %) have a normal body weight, while 4.4 % are undernourished, and 43.6 % belong to the overweight and obese category, which indicates a high prevalence of risky body composition in the population.

Figure 1 shows the representation of children who meet the 24-hour movement guidelines individually and in combination. The highest percentage of compliance is registered with the combination of physical activity + sleep (40.34 %), while full compliance with all three recommendations is met by only 8.45 % of the respondents. In isolation, only physical activity is met by 21.26 %, while the lowest representation is with the recommendation for screen time (1.45 %). The category of "no recommendation" includes 6.52 % of children. In order to determine the degree of association between fitting the 24-hour movement guidelines and various components of physical fitness in

second-year students, a series of multivariate linear regression analyses were conducted, controlling for age, sex, and body mass index (BMI).

Table I. Descriptive characteristics of participants and proportion of participants.

Variables	Mean	SD
Age (years)	9.70	0.70
Height (cm)	142.16	8.27
Body weight (kg)	40.28	10.73
BMI (kg/ m ²)	19.73	3.81
BMIz	0.00	0.99
Underweight (n; %)	18	4.4 %
Normal weight (n; %)	219	52.0 %
Overweight/obese (n; %)	177	43.6 %
MVPA (min/day)	89.87	48.85
Screen time (h /day)	3.69	1.82
Sleep duration (h/day)	9.31	2.49
Sit-and reach (cm)	14.55	6.73
Standing Long Jump (cm)	15.46	3.54
4 _ 10-m shuttle run	118.47	23.68
Grip strength (kg)	14.23	1.75
20meter shuttle run (VO ₂)	46.75	3.59
Sit ups (times/30 s)	14.73	4.61
Muscular fitness (z-score)	0.85	1.16
Physical fitness (z-score)	0.00	2.76

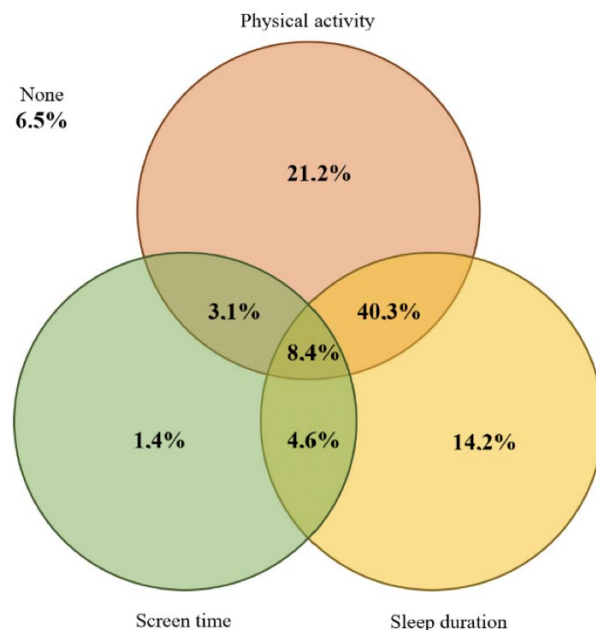


Fig. 1. Venn diagram showing the proportion (%) of participants meeting the guidelines; physical activity, recreational screen time, and sleep duration guidelines; and combinations of these recommendations. Legend: The guidelines are: ≥ 60 min/day of moderate to vigorous physical activity; no more than 2 h/day of recreational screen time; and 9–11 h/sleep for children, 8–10 h/sleep for adolescents. The sum of each circle is equivalent to the % meeting each individual recommendation (i.e., 73.2 % for physical activity, 17.6 % for screen time, and 67.6 % for sleep duration).

The review of Tables II to V, shows that the compliance with the recommendation for moderate to vigorous physical activity (MVPA) alone is the most consistent and statistically significant predictor of improvement in all components of physical fitness. Namely, moderate to vigorous physical activity (MVPA) significantly predicted greater explosive power ($\beta = 0.004$, $p < 0.001$), better coordination, speed and agility, assessed through the 4×10 -m shuttle run test ($\beta = -0.647$, $p < 0.001$), higher muscle strength assessed through the grip strength test ($\beta = 0.024$, $p = 0.001$), greater cardiorespiratory endurance ($\beta =$

1.15, $p = 0.001$), higher values of muscular endurance of abdominal musculature ($\beta = 1.33$, $p = 0.005$) and composite indices for muscular (z-score: $\beta = 0.54$, $p < 0.001$) and total physical fitness (z-score: $\beta = 1.19$, $p < 0.001$).

Combined adherence to all three recommendations (MVPA + limited screen time + adequate sleep) was statistically significant only in predicting cardiorespiratory fitness ($\beta = 1.35$, $p = 0.014$), coordination, speed and agility ($\beta = -0.647$; $p = 0.021$) and the z-score for total physical fitness ($\beta = 1.00$, $p = 0.044$), suggesting a potential synergistic effect.

Table II. Regression coefficients representing associations between 24-hour movement guideline adherence and physical fitness outcomes, adjusted for age, sex, and BMI (sit-and reach and standing long jump).

Variables	Sit-and reach (cm)				Standing Long Jump (cm)			
	β	(95 %CI)	P	β	(95 %CI)	P		
None	,001	-,002	,005	,059	-,001	-,002	,000	,158
MVPA	,003	-,004	,009	,408	,004	,002	,006	,000
Screen time	,008	,003	,014	,004	,000	-,002	,002	,804
Sleep	-,002	-,009	,005	,579	-,001	-,003	,002	,599
MVPA + Screen time	,001	-,002	,004	,461	,001	,000	,001	,166
MVPA + Sleep	-,002	-,009	,006	,651	,002	-,001	,004	,187
Screen time + Sleep	,002	-,001	,005	,211	,000	-,001	,001	,547
MVPA + Screen time + Sleep	,005	,000	,009	,032	,001	-,001	,002	,334

Note. MVPA, Screen time, and Sleep are dummy predictors (0 = does not meet the recommendation; 1 = meets the recommendation) representing adherence to each component of the 24-hour movement guidelines.

Table III. Regression coefficients representing associations between 24-hour movement guideline adherence and physical fitness outcomes, adjusted for age, sex, and BMI (4×10 -m shuttle run and grip strength).

Variables	4 x 10-m shuttle run (s)				Grip strength (kg)			
	β	(95 %CI)		P	β	(95 %CI)		P
None	,517	-,085	1.11	,092	-,008	-,016	,000	,055
MVPA	-,647	-,977	-,317	,000	,024	,010	,038	,001
Screen time	-,355	-,754	,044	,081	,012	,000	,024	,055
Sleep	-,267	-,583	,048	,097	,005	-,011	,020	,557
MVPA + Screen time	,006	-,837	,850	,989	,003	-,002	,009	,241
MVPA + Sleep	-,358	-,659	-,057	,020	,010	,203	-,006	,203
Screen time + Sleep	-,542	-1.25	,176	,139	,003	-,003	,010	,304
MVPA + Screen time + Sleep	-,647	-1.19	-,100	,021	,008	-,001	,017	,081

Note. MVPA, Screen time, and Sleep are dummy predictors (0 = does not meet the recommendation; 1 = meets the recommendation) representing adherence to each component of the 24-hour movement guidelines.

Table IV. Regression coefficients representing associations between 24-hour movement guideline adherence and physical fitness outcomes, adjusted for age, sex, and BMI (20 meter shuttle run VO₂ and sit ups times/30 s).

Variables	20meter shuttle run (VO ₂)				Sit ups (times/30 s)			
	β	(95 %CI)		P	β	(95 %CI)		P
None	-1.96	-3.14	-0.77	,001	-1.07	-2.77	0.64	,219
MVPA	1.15	0.49	1.81	,001	1.33	0.40	2.27	,005
Screen time	0.66	-0.13	1.45	,103	-0.21	-1.33	0.92	,720
Sleep	0.83	0.20	1.45	,010	0.25	-0.65	1.14	,586
MVPA + Screen time	0.37	-1.31	2.05	,664	0.47	-1.91	2.85	,699
MVPA + Sleep	0.58	-0.02	1.18	,058	0.50	-0.36	1.35	,254
Screen time + Sleep	0.63	-0.80	2.06	,388	-0.62	-2.65	1.41	,549
MVPA + Screen time + Sleep	1.35	0.27	2.43	,014	0.77	-0.76	2.31	,323

Note. MVPA, Screen time, and Sleep are dummy predictors (0 = does not meet the recommendation; 1 = meets the recommendation) representing adherence to each component of the 24-hour movement guidelines.

Table V. Regression coefficients representing associations between 24-hour movement guideline adherence and physical fitness outcomes, adjusted for age, sex, and BMI (muscular fitness and physical fitness).

Variables	Muscular fitness (z-score)				Physical fitness (z-score)			
	β	(95 %CI)		P	β	(95 %CI)		P
None	-,449	-,912	,015	,058	-0.96	-2.04	0.13	,084
MVPA	,540	,286	,793	,000	1.19	0.59	1.78	,000
Screen time	,180	-,127	,486	,250	0.57	-0.15	1.29	,121
Sleep	-,085	-,329	,159	,494	0.08	-0.50	0.65	,794
MVPA + Screen time	,388	-,261	1,037	,241	1.14	-0.38	2.66	,141
MVPA + Sleep	,135	-,098	,368	,254	0.33	-0.21	0.88	,233
Screen time + Sleep	,206	-,349	,760	,466	0.12	-1.18	1.42	,859
MVPA + Screen time + Sleep	,210	-,209	,629	,325	1.00	0.03	1.98	,044

Note. MVPA, Screen time, and Sleep are dummy predictors (0 = does not meet the recommendation; 1 = meets the recommendation) representing adherence to each component of the 24-hour movement guidelines.

However, this combination was not significantly associated with individual fitness components, such as muscular strength and endurance, implying that the cumulative effect may only be manifested in the composite indices.

Regarding screen time recommendations, isolated adherence to this guideline did not result in a statistically significant effect on any component of physical fitness, except flexibility ($\beta = 0.008$; $p = 0.004$). Although the positive effect of screen time on flexibility is statistically significant, it does not correspond to biological expectations, which may indicate unknown mediating factors or confounding variables.

Also, sleep duration was shown to be a significant predictor only of cardiorespiratory fitness, as measured by VO_{2max} ($\beta = 0.825$; $p = 0.010$), while it was not associated with other fitness components. Combinations of two recommendations, such as physical activity and sleep or physical activity and screen time, were not associated with significant improvements in most fitness components, except for better coordination, speed, and agility assessed through the 4 × 10-m shuttle run test (MVPA + sleep : $\beta = -0.358$; $p = 0.020$), indicating that the maximum effect is obtained either by isolated fulfillment of MVPA or by complete compliance with all guidelines.

DISCUSSION

This study provides a contribution to the expansion of scientific knowledge in the domain of the association between compliance with 24-hour movement guidelines adherence and physical fitness in children in the second educational period (9 to 11 years). The results obtained confirm the hypothesis that compliance with these guidelines, especially the moderate to vigorous physical activity component, is crucial for improving various aspects of physical fitness, such as cardiorespiratory fitness, muscle

strength, coordination, speed, agility and overall physical development. The relationship between these guidelines and physical fitness is complex, with different combinations of adherence yielding different results.

The analysis showed that only 8.45 % of respondents met all three recommendations (physical activity, limited screen time, and optimal sleep duration), which is consistent with the results of Zhao *et al.* (2024), who found a very low overall compliance rate of 7.1 %, with boys, younger children, and certain regions showing higher adherence to 24-hour movement guidelines than girls, adolescents, and others. The judge[L1] emphasized that adherence to these guidelines positively impacts various health indicators, including physical fitness, along with other aspects such as adiposity, cardiometabolic health, and mental health. This low rate is a clear indicator of the need for holistic approaches in the design of intervention programs and public health policies aimed at increasing active lifestyles in children (Carson *et al.*, 2017; Rollo *et al.*, 2020; Kuzik *et al.*, 2022; Zhao *et al.*, 2024).

The results further indicate that the moderate to intensive physical activity is the most consistent and strongest predictor for every component on physical fitness. In particular, the moderate to intensive physical activity was significantly associated with cardiorespiratory fitness, coordination, speed, agility, the explosive lower limb strength, strength on the upper limbs and muscles endurance of the abdominal muscles. These findings are relevant with numerous previous studies (Carson *et al.*, 2017; Tanaka *et al.*, 2020; Mateo-Orcajada *et al.*, 2022; Chen *et al.*, 2022; Zhao *et al.*, 2024; Naito *et al.*, 2025; Kuzik *et al.*, 2025) which emphasize the central role of the physical activity in determining the physical fitness with the young population.

The positive association between screen time and flexibility appears as an interesting and at the same time

unexpected finding, which is inconsistent with biological assumptions as well as with empirical evidences so far. This phenomenon may be the result of the action of unidentified mediating factors or confounding variables. It is also possible that part of the time in front of the screen represents a period of passive rehabilitation after physical activity, which could artificially strengthen the statistical relationship between these two phenomena. Given this, additional research is needed that will apply objective methods to assess sedentary behaviour and physical activity, to establish if this association is real or a consequence of methodical limitations (Bai *et al.*, 2016).

As for the sleep duration, statistically significant effect was determined only on cardiorespiratory fitness, which indicates on the importance of the night regeneration for maintaining the aerobic capacity.

The combined adherence to everyone of the three recommendations resulted with highest values on the total physical fitness, cardiorespiratory endurance and coordination speed and agility, which confirms synergistic effect at integrated application on the healthy lifestyle habits. These results coincide with certain previous research works which indicate that the fulfillment of all three recommendations (physical activity, limited screen-time and optimal sleep duration) is associated with better physical fitness, although the effect itself is not so much emphasized as only the fulfillment of MVPA instructions (Tanaka *et al.*, 2020; Zhao *et al.*, 2024).

However, some of the present research results differ from the findings of Tanaka *et al.* (2020), who found no significant association between 24-hour movement guideline adherence and muscle strength in children. These discrepancies are most likely to stem from the differences in methodological approach and sample characteristics between studies. Tanaka *et al.* (2020), used objective methods to measure physical activity (accelerometers), while our study relied on self-report, which may lead to an underestimation of the actual level of activity (Poitras *et al.*, 2016). In addition, the age and sports involvement of the respondents can influence the obtained associations, because of the biological maturity and training the status significantly modulates muscle strength. These methodological differences emphasize the need for future research works to use standardized and combined measurement approaches for greater precision and comparability of results.

As for the screen-time, these findings do not agree with the study of Aggio *et al.* (2012), who found that the excessive digital devices use is connected with reduced coordination, agility and speed. However, in the respondents

who combined all three recommendations, it is noticed that there is an improvement in coordination, agility and speed, which suggests that the elimination of sedentary behavior and quality of sleep can improve the effect of the physical activity (Carson *et al.*, 2017). This interaction supports the hypothesis that the reduction of sedentary time is not enough, but it must be accompanied with the increase of physical activity intensity and quality of sleep so as optimal fitness results to be achieved (Chen *et al.*, 2022).

Although the present research provides significant empirical insights, its cross-sectional design represents a methodological limitation, as it does not allow assessing the direction of casual associations between the analyzed variables. Hence, any associations identified should be interpreted as correlational rather than causal. In addition, physical activity and sleep data were obtained through self-report and parental reporting, which carries the risk of bias in precision, recall, and socially desirable responses (Tremblay *et al.*, 2016).

Along with that, the applied tool for measuring physical activity has a limited ability to distinguish the intensity and duration of activities, which may partially affect the accuracy of the obtained data. The lack of objective measurements, such as accelerometers, actigraph, or polysomnography, limits the possibility of a complete assessment of 24-hour movement patterns and their association to fitness components. In that direction, future research should apply longitudinal designs and validated objective instruments for monitoring physical activity, sleep and sedentary behaviour. Such kind of approach will allow a deeper and more precise understanding of the 24-hour movement dynamics and its effect on the physical, cognitive and emotional development of children (Chen *et al.*, 2022). The results clearly show that an integrated approach by simultaneously adhering to physical activity recommendations, limiting sedentary behavior and optimizing sleep is the most effective model for promoting physical fitness with children. This holistic approach should be incorporated into public health and education strategies through specific interventions such as active classrooms, digital activity tracking devices, and establishing stimulating urban infrastructure for spontaneous and organized movement (Rollo *et al.*, 2020; Shen *et al.*, 2020).

In order to understand the long-term impact of these factors, future research works should be based on longitudinal patterns and include psychophysiological indicators (e.g. heart rate variability, sleep stages, neurochemical markers), in order to describe in detail the adaptations of the child's organism. It is also necessary to examine more profoundly the role of digital media as a risk

factor, but also as a potential educational tool in shaping motivation and behavior related to physical activity. Finally, it can be concluded that this research valorizes the concept of 24-hour movement as an integrated and multidimensional model with great potential for improving health, functionality and quality of children's lifestyle.

CONCLUSIONS

The research results confirm that the 24-hour movement guideline adherence has a significant association with the physical fitness in children aged 9 to 11. Among the three components, it is the moderate to intensive physical activity that showed the strongest and most consistent predictor for higher levels of cardiorespiratory capacity, muscular strength, endurance and motoric efficiency. The combined fulfillment of every one of the three recommendations for physical activity, limited screen-time and appropriate sleep-time resulted with most favorable values on the general physical fitness, which indicates potential synergistic effect.

Despite that screen-time and sleep duration showed selectively influence on separate components, their role in the concept of integrated movement in the course of the day should not be neglected. The low representation of children who fulfill all three recommendations (only 8.45 %) indicates serious public health challenges and emphasizes the need of multisectoral interventions.

These findings valorize the holistic approaches application in promoting physical health with children emphasizing the need of longitudinal research with objective measurements, aiming to achieve more precise assessment of cause-and-effect mechanisms and to initiate policies and educational practices based on evidence.

ACKNOWLEDGEMENTS. We are very grateful to experts for their appropriate and constructive suggestions to improve this template.

KASTRATI, A.; GASHI, N.; GONTAREV, S. y GEORGIEV, G. Adherencia a las directrices de actividad física de 24 horas y su efecto en la aptitud física de niños de la República de Macedonia del Norte. *Int. J. Morphol.*, 44(4):1114-1121, 2026.

RESUMEN: El objetivo de este estudio fue determinar la asociación entre la adherencia a las directrices de actividad física de 24 horas y los diferentes componentes de la aptitud física en niños de 9 a 11 años en la República de Macedonia del Norte. El estudio incluyó a 414 participantes, cuyos componentes de aptitud física se evaluaron mediante una batería estandarizada de pruebas (aptitud cardiorrespiratoria, fuerza muscular, resistencia, flexibilidad, coordinación, agilidad y velocidad). Se recopilieron

datos sobre actividad física, tiempo frente a la pantalla y duración del sueño mediante un cuestionario estandarizado. El análisis se realizó mediante regresión lineal, controlando la edad, el sexo y el IMC. Los resultados mostraron que solo el 8,45 % de los participantes cumplió con las tres recomendaciones. El cumplimiento de las recomendaciones de actividad física moderada a vigorosa fue el predictor más consistente de mejores resultados en todos los componentes de la aptitud física. El cumplimiento combinado de las tres guías se asoció con mejores valores de resistencia cardiorrespiratoria, aptitud motora y aptitud física general, lo que sugiere un posible efecto sinérgico. El tiempo frente a pantallas y la duración del sueño tuvieron efectos limitados y selectivos. La investigación destaca los beneficios de un enfoque integral que incluya todos los aspectos del movimiento durante 24 horas para promover la salud física en los niños. Al mismo tiempo, identifica la necesidad de intervenciones y futuros estudios longitudinales con mediciones objetivas para comprender mejor estas relaciones.

PALABRAS CLAVE: Aptitud física; Niños; Actividad física; Sueño; Tiempo frente a la pantalla; Guías de movimiento durante 24 horas.

REFERENCES

- Aggio, D.; Ogunleye, A. A.; Voss, C. & Sandercock, G. R. H. Temporal relationships between screen-time and physical activity with cardiorespiratory fitness in English schoolchildren: A 2-year longitudinal study. *Prev. Med.*, 55(1):37-9, 2012.
- Álvarez-Bueno, C.; Hillman, C. H.; Cervero-Redondo, I.; Sánchez-López, M.; Pozuelo-Carrascosa, D. P. & Martínez-Vizcaino, V. Aerobic fitness and academic achievement: A systematic review and meta-analysis. *J. Sports Sci.*, 38(5):582-9, 2020.
- Bai, Y.; Chen, S.; Laurson, K. R.; Kim, Y.; Saint-Maurice, P. F. & Welk, G. J. The associations of youth physical activity and screen time with fatness and fitness: The 2012 NHANES National Youth Fitness Survey. *PLoS One*, 11(1):e0148038, 2016.
- Cadenas-Sanchez, C.; Mena-Molina, A.; Torres-Lopez, L. V.; Migueles, J. H.; Rodriguez-Ayllon, M.; Lubans, D. R. & Ortega, F. B. Healthier minds in fitter bodies: A systematic review and meta-analysis of the association between physical fitness and mental health in youth. *Sports Med.*, 51(12):2571-605, 2021.
- Carson, V.; Chaput, J.-P.; Janssen, I. & Tremblay, M. S. Health associations with meeting new 24-hour movement guidelines for Canadian children and youth. *Prev. Med.*, 95:7-13, 2017.
- Caspersen, C. J.; Powell, K. E. & Christenson, G. M. Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Rep.*, 100(2):126-31, 1985.
- Chen, Z.; Chi, G.; Wang, L.; Chen, S.-T.; Yan, J. & Li, S. The combinations of physical activity, screen time, and sleep, and their associations with self-reported physical fitness in children and adolescents. *Int. J. Environ. Res. Public Health*, 19(10):5783, 2022.
- García-Hermoso, A.; Ramírez-Campillo, R. & Izquierdo, M. Is muscular fitness associated with future health benefits in children and adolescents? A systematic review and meta-analysis of longitudinal studies. *Sports Med.*, 49(7):1079-94, 2019.
- García-Hermoso, A.; Izquierdo, M. & Ramírez-Vélez, R. Tracking of physical fitness levels from childhood and adolescence to adulthood: A systematic review and meta-analysis. *Transl. Pediatr.*, 11(4):474-86, 2022.
- Gontarev, S.; Kalac, R.; Velickovska, L. A. & Zivkovic, V. Physical fitness reference standards in Macedonian children and adolescents: The MAKFIT study. *Nutr. Hosp.*, 35(6):1275-86, 2018.

- Kuzik, N.; da Costa, B. G. G.; Hwang, Y.; Verswijveren, S. J. J. M.; Rollo, S.; Tremblay, M. S.; Bélanger, S.; Carson, V.; Davis, M.; Hornby, S.; *et al.* School-related sedentary behaviours and indicators of health and well-being among children and youth: a systematic review. *Int. J. Behav. Nutr. Phys. Act.*, 19(1):40, 2022.
- Kuzik, N.; Duncan, M. J.; Beshara, N.; MacDonald, M.; Silva, D. A. S. & Tremblay, M. S. A systematic review and meta-analysis of the first decade of compositional data analyses of 24-hour movement behaviours, health, and well-being in school-aged children. *J. Act. Sedent. Sleep Behav.*, 4(1):4, 2025.
- Mateo-Orcajada, A.; González-Gálvez, N.; Abenza-Cano, L. & Vaquero-Cristóbal, R. Differences in physical fitness and body composition between active and sedentary adolescents: A systematic review and meta-analysis. *J. Youth Adolesc.*, 51(2):177-92, 2022.
- Naito, T.; Aoyagi, K.; Oka, K. & Ishii, K. Differences between meeting 24-hour movement guidelines and physical fitness levels among Japanese elementary school children. *PLoS One*, 20(12):e0337972, 2025.
- Nevill, A. M.; de Menezes-Junior, F. J.; de Jesus, I. C.; de F. A. Lopes, M.; Corazza, P. R. P.; Tadiotto, M. C.; Mota, J. & Leite, N. Predicting cardiorespiratory fitness using the 20-m shuttle run test: New insights using nonlinear allometry. *Med. Sci. Sports Exerc.*, 53(8):1624-1629, 2021.
- Ortega, F. B.; Ruiz, J. R.; Castillo, M. J. & Sjöström, M. Physical fitness in childhood and adolescence: A powerful marker of health. *Int. J. Obes.*, 32(1):1-11, 2008.
- Poitras, V. J.; Gray, C. E.; Borghese, M. M.; Carson, V.; Chaput, J. P.; Janssen, I.; Katzmarzyk, P. T.; Pate, R. R.; Connor Gorber, S.; Kho, M. E.; *et al.* Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Appl. Physiol. Nutr. Metab.*, 41(Suppl. 3):S197-S239, 2016.
- Rollo, S.; Antsygina, O. & Tremblay, M. S. The whole day matters: Understanding 24-hour movement guideline adherence and relationships with health indicators across the lifespan. *J. Sport Health Sci.*, 9(6):493-510, 2020.
- Ruiz, J. R.; Castro-Piñero, J.; España-Romero, V.; Artero, E. G.; Ortega, F. B.; Cuenca, M. M.; Jiménez-Pavón, D.; Chillón, P.; Girela-Rejón, M. J.; Mora, J.; Gutiérrez, A.; Suni, J.; Sjöström, M. & Castillo, M. J. Field-based fitness assessment in young people: the ALPHA health-related fitness test battery for children and adolescents. *Br. J. Sports Med.*, 45(6):518-24, 2011.
- Shen, H.; Yan, J.; Hong, J. T.; Clark, C.; Yang, X. N.; Liu, Y. & Chen, S.-T. Prevalence of physical activity and sedentary behavior among Chinese children and adolescents: Variations, gaps, and recommendations. *Int. J. Environ. Res. Public Health*, 17(9):3066, 2020.
- Tanaka, C.; Tremblay, M. S.; Okuda, M. & Tanaka, S. Association between 24-hour movement guidelines and physical fitness in children. *Pediatr. Int.*, 62(12):1381-7, 2020.
- Tremblay, M. S.; Carson, V.; Chaput, J. P.; Connor Gorber, S.; Dinh, T.; Duggan, M.; Faulkner, G.; Gray, C. E.; Gruber, R.; Janson, K.; *et al.* Canadian 24-hour movement guidelines for children and youth: An integration of physical activity, sedentary behaviour, and sleep. *Appl. Physiol. Nutr. Metab.*, 41(6 Suppl. 3):S311-27, 2016.
- Utesch, T.; Bardid, F.; Büsch, D. & Strauss, B. The relationship between motor competence and physical fitness from early childhood to early adulthood: A meta-analysis. *Sports Med.*, 49(4):541-51, 2019.
- Zhao, H.; Wu, N. & Haapala, E. A. Association between meeting 24-h movement guidelines and health in children and adolescents aged 5–17 years: a systematic review and meta-analysis. *Front. Public Health*, 12:1351972, 2024.

Corresponding author:

Seryozha Gontarev
Faculty of Physical Education, Sport and Health
Ss. Cyril and Methodius University
1000 Skopje
REPUBLIC OF NORTH MACEDONIA

E-mail: gontarevserjoza@gmail.com