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Original Article

Exploring urban-rural differences in 24-h movement behaviours among tunisian preschoolers: Insights from the SUNRISE study

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ABSTRACT

Little is known about differences in physical activity among children from urban and rural areas in low-to middle-income countries and some previous investigations revealed disparities in physical activity levels among children and adolescents residing in urban and rural environments. We aimed to: (i) assess the proportion of preschool-aged children (3.0–4.9 years) meeting the global movement guidelines, (ii) evaluate the feasibility of the methods for the SUNRISE study, (iii) examine gender- and urban-rural differences in health and behavior outcomes. Urban and rural location was based on national classifications. Physical activity (waist-worn ActiGraph); sleep duration, screen time and movement behaviors; Gross and fine motor skills (Lower body strength and mobility, Supine-Timed up and go [S-TUG], One-leg standing balance test, hand grip dynamometer, 9-hole peg-board test); and executive functions (visual-spatial working memory and inhibition) were assessed in 112 preschoolers ($n = 50$ boys, 33 urban), ($n = 62$ girls, 41 urban). The results showed that only 18% of children met all movement guidelines, with 53% and 41% meeting the recommendations for sedentary screen time and total physical activity, respectively. A large proportion of children (81%) met the recommended sleep duration of 10–13 hours (h) per day. There is a clear need to promote healthy movement behaviours among preschool-aged children through targeted interventions that address their unique challenges related to gender and urban/rural residence.

1. Introduction

Childhood overweight and obesity is a growing public health concern in Tunisia.[1] A study conducted in the metropolitan region of Tunis[1] revealed that 19.7% of elementary schoolchildren were overweight, while 5.7% were obese. The authors identified various risk factors associated with overweight, such as the high education and occupational status of parents, and unhealthy dietary habits such as the excessive consumption of bread, snacks, and soft drinks.[1]

It is well established that a lifestyle characterized by high levels of physical activity, low levels of sedentary behavior, and sufficient amounts of sleep is important for optimal health.[2] Although movement-related behaviours (i.e., physical activity, sedentary behavior, and sleep) have typically been studied in isolation, compelling evidence shows that these behaviours interact with one another to impact health.[3] Sedentary behavior, particularly excessive screen time, has also been linked to overweight and obesity in youth.[4] Inadequate sleep has been shown to impact metabolism and hormones, leading to an increase in appetite and a decrease in energy expenditure, thereby contributing to obesity in children.[5] To promote a healthy weight in children, it is important to encourage regular physical activity, limit sedentary time, especially screen time, and ensure sufficient sleep. Indeed, tackling childhood obesity requires a comprehensive approach that includes promoting healthy diets, physical activity, and creating supportive environments to encourage healthy behaviors.[6]

Following the introduction of the WHO's 2019 24-hour (h) movement guidelines for 3–4 year olds, there is evidence that a relatively small proportion of children adhere to these recommendations. A study conducted[3] revealed that approximately 13% of children in Canada fulfilled all the prescribed 24-h movement behavior guidelines, while a similar study in Australia.[7] indicated that only about 14% of children met these

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Abbreviationlist

WHO	World Health Organization
HICs	high-income countries
LMICs	middle-income countries
SUNRISE	the International Study of Movement Behaviors in Early Childhood
EYT	the Early Years Toolbox
S-TUG	Supine-Timed up and go
UR	urban
RU	rural
BMI	body mass index
HAZ	height-for-age z score
WAZ	weight-for-age z score
BAZ	BMI-for-age z score
LPA	light-intensity physical activity
MPA	Moderate intensity physical activity per day (minutes)
VPA	Vigorous intensity physical activity per day (minutes)
MVPA	moderate-vigorous intensity physical activity
TPA	total physical activity
SB	sedentary behavior
SST	sedentary screen time

guidelines. The majority of these investigations have been carried out within high-income countries (HICs), with a scarcity of studies focusing on low to middle-income countries (LMICs).

In Africa, certain research conducted in low- and middle-income countries[8–10] has revealed disparities in physical activity levels among children and adolescents residing in urban (UR) and rural (RU) environments. However, it remains uncertain whether these discrepancies extend to preschool-aged children (aged 3.0–4.9 years). Furthermore, in low- and middle-income countries, there is a common perception that children in rural areas exhibit higher levels of physical activity and reduced sedentary behavior compared to their urban counterparts. A comparative analysis between urban and rural regions in Tunisia is important, to enhance knowledge on environmental and social contexts for physical activity. It is also important to conduct this analysis separately for boys and girls, since their specific experiences and challenges in each geographical context can differ. Currently, it remains to be determined whether significant disparities exist in adhering to the 24-h movement behavior guidelines between urban and rural settings in Tunisia.

Despite physical activity (PA) being essential for health, there are significant inequalities between countries and world regions in their capacity to promote PA.[11] Coordinated efforts are needed to reduce these inequalities and improve the global capacity for PA promotion.[6]Additionally, there is a clear need to promote healthy movement behaviors among preschool-aged children through targeted interventions that address their unique challenges related to gender and urban/rural residence. Little is known about differences in physical activity among children from urban and rural areas in low-to middle-income countries, and some previous investigations have revealed disparities in physical activity levels among children and adolescents residing in urban and rural environments.[12] Therefore, understanding these differences and implementing tailored interventions is crucial for promoting physical activity and improving health outcomes among children in diverse settings.[13]

The International Study of Movement Behaviors in Early Childhood (SUNRISE) was initiated to meet this need, involving countries with diverse economic backgrounds, including Tunisia. SUNRISE aims to offer a thorough understanding of movement behaviors and their impact on various health and developmental outcomes in young children from a global standpoint.[13]

Using data collected for the Tunisian pilot study, this study aimed to (i) determine the proportion of preschool-aged children adhering to the WHO guidelines in Tunisia; (ii) examine the feasibility of adopting the SUNRISE study protocol in the Tunisian context; and, (iii) investigate the gender and urban-rural differences in children's movement behaviours, fine and gross motor skills, and cognition.

2. Material and methods

2.1. Study design

Cross-sectional data were collected in two high- and two low-income urban and rural regions in Tunisia: Mannar and El Omrane Tunis, Cité Amal Tunis (urban) and Cité Zahrouni and Sijoumi (rural). We classified Tunisian regions as urban and rural using local authority-defined criteria. Urban areas depended on factors such as population density and developed infrastructure, while rural zones had lower population density, limited modern infrastructure, and relied on agriculture. These criteria were consulted with local authorities for precise classification. Children and parents (or primary guardians) were recruited from two kindergartens in Zahrouni and three kindergartens in Tunis.

2.2. Ethical approval

All procedures were approved by the Ethics Committee of the Faculty of Medicine of Sousse (CEFMS 121/2022). The study was conducted in accordance with the latest version of the Declaration of Helsinki. All participants and their parents/legal representatives were fully informed about the protocol and its potential risks and benefits.

Data were collected from children at the kindergartens during schooling days. Parent questionnaires were administered by interviewers and completed at a time convenient to the child's home or preschool. Data were collected by a principal interviewer and two assistants who were trained using a standardized research protocol. All questionnaires were translated into Arabic to ensure that participants understood the questions and could provide accurate responses.

The study was carried out during winter (November 2022 to January 2023). Parents were invited to attend a meeting at the kindergarten where they were provided with information about the study. Following the meeting, appointments were made with parents who expressed their willingness to participate in the study. Eligible children were invited to participate in the study and written informed consent was obtained from their parents.

2.3. Anthropometry

We used customizable and repositionable adhesive measuring tapes to measure the height of children. The weight of children was measured using a calibrated scale SECA Viva 750. Measurements were taken when children were wearing light clothing and no shoes to ensure accuracy. Anthropometric indicators (height-for-age *z*-score, weight-for-age *z*-score, body mass index *z*-score) were then calculated based on the WHO child growth standards.[14]

2.4. Accelerometry

Time spent in physical activity and sedentary behavior were determined from the accelerometry data collected using Actigraph GT3X accelerometers (Actigraph LLC, Pensacola, FL, USA) worn on the right hip for five consecutive days. The accelerometers were programmed to capture data at a sampling rate of 30 Hz, and data were downloaded and analyzed in 15-second (s) epochs using a low-frequency filter via ActiLife software (version 6.1.2.1, ActiGraph Corporation). To be included in the analyses, a child was required to have worn the accelerometer for at least a 24-h day without removing it during the nighttime period (confirmed via visual inspection of the acceleration data), and had a minimum of 6 h

of valid wear time during the standardized waking time window from 07:00 to 21:00 (determined based on parent-reported bedtime and wake-up time). Any periods with 20 minutes (min) or more of consecutive zero counts during the waking time window were classified as non-wear time and excluded from the analyses. The accelerometer cut-points by Pate et al.[15] were applied to classify activity intensity categories (sedentary, light, moderate or vigorous).[15]

2.5. Executive function

The Early Years Toolbox EYT (www.eytoolbox.com.au), was used to assess two types of executive function skills in this study, (i) visual-spatial working memory assessed by the Mr Ant game, (ii) inhibition assessed by the GoNo-Go game. Each game took around 10 min to complete. The research assistant explained each game which has a built-in practice period at the start. The tasks were performed in a quiet environment.[16]

2.6. Gross motor

2.6.1. Lower body strength and mobility: standing long jump

In this test, a line is marked on the ground and the child stands behind it. The child then jumps with both feet as far as possible. The child is given one practice jump and two attempts. The average of the recorded distances is used as the final score.

2.6.2. Mobility and posture: Supine-Timed up and go (S-TUG)

In this test, a line is drawn 3 m away from a wall, and a large target is marked on the wall at the child's eye level. The child starts lying on their back with their feet on the line. At the start, the child gets up as quickly as possible, runs and touches the target, and then runs backwards on the 3-m line. The child is given one practice trial and two attempts to perform the test.

2.6.3. Posture: one-leg standing balance test

During the test, the child stands on one leg with their arms held along their body. The free leg is not allowed to be hooked around the standing leg, but the arms can move to the sides. Timing begins when the free leg leaves the floor, and the test is stopped if the child moves the standing leg or hooks the free leg around the other leg. If the child maintains balance for 30 s, the evaluation is stopped, and the test is repeated on the other leg. The length of time the child spends balancing on each leg is recorded, and the average time is used as the final score.

2.6.4. Upper body strength: hand grip dynamometer

This test measures the ability of the hand and arm muscles to produce the tension and power needed to maintain posture. During the test, the child must continuously squeeze the grip dynamometer with full force using their right hand for at least 3 s without letting their arms touch their body. One practice and two trials are performed with each hand.[17]

2.7. Fine motor skills manipulation: 9-hole peg-board test

This test measures the speed and precision of hand movements during the task of picking up nine pegs one at a time and placing them into a pegboard and then returning them. The evaluator starts the timer as soon as the child begins the task and stops it when the last peg is removed from the well. The test has been found to be reliable and valid for assessing fine motor skills in children.[6]

2.8. The feasibility of the protocol

In order to assess the feasibility of the protocol, we evaluated three key factors. First, we determined the proportion of children who had valid accelerometry data, indicating their compliance with wearing and using the accelerometers as instructed. Second, we assessed the proportion of children who successfully completed the executive function tasks, specifically the two games designed to measure cognitive abilities. Finally, we examined the proportion of children who had valid and complete data for both gross and fine motor skills assessments. These evaluations allowed us to gauge the practicality and effectiveness of the protocol in capturing accurate and reliable data for various aspects of the study.

2.9. Questionnaire

The SUNRISE questionnaire was administered to the child's parent or primary guardian. The questionnaire was translated into the two most common local languages, Arabic and French, and parents were asked to choose the language they felt most comfortable with. Caregivers were also asked to report on their child's activities before bedtime, including time spent restrained or tied, time spent sitting, and time spent engaging in screen time.[18] The parent questionnaire asked about the frequency of use of screen-based devices that the caregiver engaged in during interactions with the child, including educating the child, calming down when the child is upset, keeping the child busy while parents get things done, engaging with the child during meals, playtime, travel time, walks, and bedtime routines. Questions relating to the eating behaviours and food security were also asked. Sleep duration was calculated based on the reported sleep schedule (bedtime, wake-up time and naps).

2.10. Statistical analysis

Data were analyzed using SPSS Statistics for Windows (V 26.0). Data were presented as mean ± standard deviation. To examine differences between boys and girls, and rural and urban, Mann-Whitney U tests (for continuous variables) and Pearson's χ^2 test (for categorical variables) were performed. Children were classified as meeting PA guidelines if they spent an average of 180 min per day in TPA, inclusive of 60 min per day of MVPA (accelerometer measured). They were classified as meeting the screen time guideline if they had less than 1 h per day of parent-reported screen time, and were getting 10–13 h of parent-reported sleep per 24-h day.

3. Results

The results of the evaluation of the three key factors to assess the feasibility of the protocol: Proportion of children with valid accelerometer data:

In total (n = 112), 80% of children had valid accelerometer data, indicating compliance with wearing and using accelerometers, of the UR boys (n = 33), 79% (26 UR boys) had valid accelerometer data. Among RU boys (n = 17), 100% had valid accelerometer data. Of the UR girls (n = 41), 61% (25 UR girls) had valid accelerometer data. Among RU girls (n = 21), 100% had valid accelerometer data. After participant distribution, it is important to note that despite efforts to balance urban and rural representation, recruiting in rural areas faced challenges due to limited accessibility, time constraints, and logistical issues in scheduling parent appointments.

3.1. Executive function tasks

For all the children (n = 112), 100% performed the executive function tasks. Among the UR boys (n = 33), 100% performed the executive function tasks. Among the RU boys (n = 17), 100% performed the executive function tasks. Among the UR girls (n = 41), 100% performed the executive function tasks. Among the RU girls (n = 21), 100% performed the executive function tasks.

3.2. Gross and fine motor skills

For all children (n = 112), 100% were assessed for gross and fine motor skills. Of the UR boys (n = 33), 100% were assessed for gross and

fine motor skills. Of the RU boys ($n = 17$), 100% were assessed for gross and fine motor skills. Of the UR girls ($n = 41$), 100% were assessed for gross and fine motor skills. Of the RU girls ($n = 21$), 100% were assessed for gross and fine motor skills.

Table 1 presents the descriptive characteristics and time spent in movement behaviors of children participating in a study, stratified by gender and residential settings. The analytical sample included 112 children, with 33 boys from urban settings, 17 boys from rural settings, 41 girls from urban settings, and 21 girls from rural settings, A total of 74 children came from urban areas and 38 children from rural areas. The analysis revealed significant differences between boys living in urban and rural areas in terms of weight, height, BMI, HAZ, BAZ, and MVPA. Meanwhile, girls living in urban areas had significantly higher age, height, BMI, HAZ, BAZ, LPA, MPA, MVPA, TPA, and SB compared to those living in rural areas. There was a significant difference between urban and rural populations in terms of BAZ, with urban children having a higher mean BAZ (0.94) compared to rural children (−0.42).

Table 2 presents the proportion of children meeting the individual and combined 24-h movement guidelines. Significant differences were observed between boys living in urban and rural areas for all three measured parameters of physical activities (≥ 60 min/day of MVPA, ≥ 180 min/day of TPA, and ≥ 60 min/day of MVPA and ≥180 min/day of TPA), with ($p \leq 0.001$). However, for girls, significant differences were found only for the parameter "≥ 60 min/day of MVPA per day a," with ($p = 0.001$), indicating that a higher proportion of girls living in urban areas met this guideline compared to those in rural areas. For the two variables sedentary screen time, and sleep duration, no significant differences were observed between boys and girls, either in urban or rural settings. However, a trend towards significance was noted for sleep duration among girls ($p = 0.056\ 5$), indicating a potential difference between girls living in urban and rural areas. Conversely, a significant difference was found for the variable "Meeting all five recommendations", showing that a higher percentage of boys living in rural areas meet all five recommendations compared to those living in urban areas ($p = 0.002$).

There was no significant difference in the performance of the inhibition task across all groups (Table 3). However, there was a significant difference in working memory between boys in urban and rural areas ($p = 0.010$), whereas there was no significant difference observed for girls. The group of girls living in rural residential settings had the highest score on the Inhibition task. The mean score for inhibition was (0.79 ± 0.20) for rural girls, which was slightly higher compared to other groups, although this difference was not statistically significant. On the other hand, the group of boys living in rural settings had the highest score on the Working Memory task. The mean score for working memory was (2.22 ± 0.75) for RU boys, which was significantly higher compared to boys living in UR residential settings (mean score: 1.76 ± 0.80) with a p-value of 0.010.

For functional mobility (Table 4), there was a significant difference between urban and rural boys, with urban boys taking a significantly shorter time to complete the test ($p = 0.028$). However, rural boys demonstrated better lower body strength than urban boys ($p = 0.002$). The difference between rural and urban girls in postural steadiness ($p = 0.001$), lower body strength ($p < 0.001$), upper body strength ($p < 0.001$) and dexterity ($p < 0.001$) were significant.

Table 1
Descriptive characteristics and time spent in movement behaviors of participating children, stratified by gender and residential settings.

Variables	All (n = 112)	Boys UR (n = 33)	Boys RU (n = 17)	p value	Girl UR (n = 41)	Girl RU (n = 21)	p value
Age	4.10 ± 0.58	3.96 ± 0.58	4.62 ± 0.48	0.073	3.83 ± 0.48	4.70 ± 0.30	**< 0.001**
Weight (kg)	18.6 ± 3.0	19.4 ± 2.8	18.0 ± 2.6	**0.035**	18.4 ± 3.4	18.2 ± 2.3	0.876
Height (cm)	107.4 ± 6.8	101.6 ± 6.1	109.0 ± 7.1	0.546	104.3 ± 6.6	112.1 ± 4.9	**< 0.001**
BMI	16.1 ± 2.0	16.8 ± 2.0	15.2 ± 1.4	**0.003**	16.8 ± 2.0	14.5 ± 1.4	**< 0.001**
HAZ	0.85 ± 1.20	1.33 ± 1.15	0.45 ± 1.08	**0.006**	0.98 ± 1.21	0.18 ± 1.00	**< 0.004**
WAZ	0.89 ± 1.26	1.09 ± 1.43	0.90 ± 1.28	0.652	0.67 ± 1.28	1.01 ± 1.09	0.211
BAZ	0.48 ± 1.37	1.00 ± 1.31	−0.17 ± 1.08	**0.003**	0.89 ± 1.26	−0.62 ± 1.05	**< 0.001**
LPA (min/day) a	88.3 ± 24.7	89.9 ± 26.9	99.6 ± 24.1	0.258	90.1 ± 20.3	66.9 ± 27.3	**0.013**
MPA (min/day) a	61.5 ± 23.8	61.9 ± 25.1	79.8 ± 7.8	**0.016**	62.0 ± 23.3	45.3 ± 19.8	**0.021**
VPA (min/day) a	18.8 ± 12.8	18.5 ± 12.6	27.3 ± 8.5	**0.070**	18.9 ± 13.9	13.9 ± 8.2	0.306
MVPA (min/day) a	80.3 ± 34.9	80.4 ± 35.9	107.1 ± 10.1	**0.014**	80.9 ± 35.9	59.2 ± 25.6	**0.032**
TPA (min/day) a	168.6 ± 55.1	170.3 ± 57.3	206.7 ± 26.6	0.052	170.9 ± 52.7	126.1 ± 52.3	**0.018**
SB (min/day) a	628.6 ± 56.3	627.8 ± 57.0	609.7 ± 47.2	0.349	624.0 ± 53.7	678.8 ± 51.5	**0.008**
SST (min/day) b	120.0 ± 33.5	70.0 ± 32.6	68.9 ± 30.8	0.992	73.5 ± 38.0	68.4 ± 29.2	0.676
Sleep (min/day) b	640.4 ± 53.5	651.0 ± 54.5	632.1 ± 39.1	0.160	627.9 ± 57.4	631.6 ± 54.5	0.452

BMI body mass index, HAZ, height-for-age z score; WAZ, weight-for-age z score; BAZ, BMI-for-age z score, LPA light-intensity physical activity, MPA Moderate intensity physical activity per day (minutes), VPA Vigorous intensity physical activity per day (minutes), MVPA moderate-vigorous intensity physical activity, TPA total physical activity, SB sedentary behavior, SST sedentary screen time. Data presented as mean (95% confidence interval). Analytical sample: a $n = 89$ (33 boys UR, 6 boys RU, 41 girls UR; 9 girls RU) b $n = 112$ (33 boys UR, 17 boys RU, 41 girls UR; 21 girls RU). Differences were tested using Mann-Whitney U tests by a gender and b residential settings; bold values indicate statistically significant at $p < 0.05$.

4. Discussion

The methods used in the SUNRISE study were found to be feasible in a Tunisian context with good compliance with the 24-h accelerometry protocol. A low proportion (18%) of Tunisian preschool-aged children comply with WHO global guidelines. We found meaningful gender and urban-rural differences in physical activity, screen time, sleep duration, gross and fine motor skills and BMI among Tunisian children**.** It is crucial to recognize the prevailing gap in comprehending variations in physical activity levels between urban and rural children in low- and middle-income countries. Previous research has reported differences in physical activity levels among children and adolescents residing in urban and rural settings. Nevertheless, the precise factors contributing to these differences may vary and could be influenced by numerous factors.[19,20]

4.1. The proportion of children meeting the WHO 24-h movement guidelines

We found that 18% of Tunisian children met all five recommendations, which is similar to Sweden (19%).[21] Compared to results from other SUNRISE studies, the proportion was higher than Bangladesh (5%),[22] Hong Kong, China (3%)[23] and Beijing, China (15%),[24] but lower than Zimbabwe (24%)[18] and South Africa (26%).[25] These differences may be explained by cultural norms, socioeconomic status, and built environment.

When examining the results by gender and location, some interesting patterns emerge. First, the comparison between urban and rural boys, indicates that rural boys have a higher percentage of compliance with the WHO integrated movement guidelines (47.1%), comparatively to urban

Table 2
Number and proportion of children meeting each of the 24-h movement guidelines, stratified by gender and residential settings.

Variables	All ($n = 89$)	Boys UR	Boys RU	p value	Girl UR	Girl RU	p value
$\geq$ 60 min/day of MVPA per day a	68 (76.4%)	18 (69.2%)	17 (100%)	**0.001**	18 (72%)	15 (71.4%)	**0.001**
$\geq$ 180 min/day of TPA a	36 (40.5%)	8 (30.8%)	14 (82.4%)	**0.001**	6 (24%)	8 (38.1%)	**0.301**
$\geq$ 60 min/day of MVPA and $\geq$ 180 min/day of TPA a	36 (40.5%)	8 (30.8%)	14 (82.4%)	**0.011**	6 (24%)	8 (38.1%)	**0.966**
$\leq$ 60 min/day of SST b	59 (52.7%)	18 (54.6%)	9 (53.0%)	**0.914**	21 (51.3%)	11 (52.4%)	**0.931**
10–13 h/day of sleep b	91 (81.3%)	28 (84.9%)	16 (94.1%)	**0.339**	32 (78.1%)	15 (71.4%)	**0.056 5**
Meeting all five recommendations b	16 (18.0%)	3 (9.0%)	8 (47.1%)	**0.002**	2 (4.9%)	3 (14.3%)	**0.198**

MVPA moderate-vigorous intensity physical activity, TPA total physical activity, SST sedentary screen time. Analytical sample: a $n = 89$ (26 boys UR, 17 boys RU, 25 girls UR; 21 girls RU) b $n = 112$ (33 boys UR, 17 boys RU, 41 girls UR; 21 girls RU); Differences between genderes and residential settings were tested using Pearson χ^2 tests.

Table 3
Scores on the executive function tasks (mean ± standard deviation).

Variables	All (n = 112)	Boys UR (n = 33)	Boys RU (n = 17)	p value	Girl UR (n = 41)	Girl RU (n = 21)	p value
Inhibition	0.67 ± 0.24	0.62 ± 0.26	0.62 ± 0.26	0.424	0.64 ± 0.24	0.79 ± 0.20	0.091
Working Memory	1.89 ± 0.74	1.76 ± 0.80	2.22 ± 0.75	**0.010**	1.80 ± 0.66	2.00 ± 0.72	0.344

Differences between gender and by gender and residential settings tested using Mann-Whitney U tests.

boys (9.0%). This suggests that the environment and lifestyle in rural areas may be more conducive to healthy behaviors in boys. Likewise, the trend of preschool Tunisian girls living in rural areas having a higher percentage of compliance with the integrated movement guidelines (14.3%) than girls in urban areas (4.9%). Girls in rural areas may have easier access to physical activities, such as farming or household chores, while girls in urban areas may be more limited in their ability to move due to population density and the lack of safe outdoor spaces. Socio-economic factors could serve as a potential explanation for these disparities, encompassing elements such as access to recreational facilities, availability of safe outdoor spaces, and the socioeconomic status of families. Studies suggest that children from lower-income families or residing in rural locales may encounter obstacles in accessing organized sports or recreational activities, thus impacting their overall physical activity levels.[26] These differences underscore the importance of considering environmental and social contexts when designing interventions to promote healthy lifestyles in children. Nonetheless, the results suggest that there may be gender- and location-specific factors that influence children's ability to meet the movement guidelines. In order to promote healthy behaviors in children, interventions must take these differences into account and be tailored to the specific needs of each group. For example, interventions in rural areas should focus on improving access to health-promoting resources, while interventions in urban areas should focus on promoting physical activity and reducing sedentary behaviors.

The Sunrise Tunisia study found that the proportion of Tunisian children who engaged in sedentary screen time was more than half (52.7%). When compared to similar studies conducted in other countries, this percentage was found to be higher than that of Bangladesh (17.5%),[22] South Africa (48.0%),[25] and Sweden (37.8%).[21] This may be due to differences in culture, parental habits and practices, the physical and social environment of children, as well as national policies and programs related to children's health and well-being. Such findings highlight the importance of implementing health promotion and prevention programs to reduce sedentary screen time among children. We should develop and implement effective interventions to encourage children to engage in physical activity and reduce their screen time. Moreover, cultural disparities in attitudes towards physical activity and outdoor play may influence activity levels among children from urban and rural areas. Cultural norms and values pertaining to physical activity can diverge between communities, influencing children's involvement in physical activities.[27]

When considering the results by gender and living environment, we found differences in sedentary screen time (SST) between boys and girls, regardless of their living environment. Boys, living in urban areas had a slightly higher percentage of SST (54.6%) compared to boys living in rural areas (53.0%), On the other hand, among girls, those living in rural areas had a a slightly higher percentage of SST (52.4%) compared to girls living in urban areas (51.3%).

In our opinion, these findings suggest that rural children may have more access to physical activity opportunities, while urban children may be more likely to engage in sedentary screen time due to limited access to other types of entertainment. Overall, the results of the study emphasize the need for interventions to boost healthy screen time habits among Tunisian children, with particular urge to focus on reducing SST in both urban and rural areas. Gender and living environment should be considered when developing such interventions to ensure they are effective and appropriate for all children.

We found that 40.5% of Tunisian children met the recommended levels of total physical activity. In comparison, Sweden had the highest proportion of children meeting recommended levels of physical activity (90%),[21] followed by Bangladesh (42%).[22] Regular physical activity has many health benefits for children.[28] Factors that may contribute to the lower proportion of children achieving recommended levels of physical activity in Tunisia, include cultural and social factors, access to sports facilities, and availability of physical education in schools. There is

Table 4
Overall scores for the gross and fine motor skill (mean ± standard deviation).

Variables	All ($n = 112$)	Boys UR ($n = 33$)	Boys RU ($n = 17$)	p value	Gril UR ($n = 41$)	Girl RU ($n = 21$)	p value
Functional mobility (s)	5.30 ± 1.41	4.88 ± 1.32	5.56 ± 1.17	**0.028**	5.70 ± 1.71	5.00 ± 0.74	0.233
Postural steadiness (s)	12.60 ± 7.12	12.24 ± 8.07	13.44 ± 7.64	0.378	10.80 ± 7.18	16.00 ± 5.12	**0.001**
Lower body strength (cm)	56.1 ± 20.8	52.8 ± 50.6	71.3 ± 15.8	**0.002**	74.1 ± 15.5	68.4 ± 15.5	**> 0.001**
Upper body strength (kg)	7.24 ± 2.52	7.37 ± 2.73	8.23 ± 2.56	0.401	6.06 ± 2.12	8.54 ± 1.98	**> 0.001**
Dexterity (s)	40.9 ± 9.7	43.1 ± 10.0	39.72 ± 9.4	0.215	43.4 ± 9.8	34.0 ± 5.2	**> 0.001**

Differences were tested using Mann-Whitney U tests; bold values indicate statistically significant at $p < 0.05$.

clearly room for improvement in promoting physical activity among Tunisian children. Encouraging physical activity through school curricula, community initiatives, and parental involvement could be an effective strategy to increase physical activity levels among children in Tunisia.

When examining the data by gender and urban/rural residence, there were statistically significant differences, with urban areas boys showing a lower proportion of meeting the recommended levels of physical activity (30.8%), compared to boys living in rural areas (82.4%). Environmental aspects, including the built environment and neighborhood safety, may also play a role in differences in physical activity between urban and rural areas. Research indicates that urban settings often offer more walkable neighborhoods and greater access to parks or playgrounds, potentially facilitating higher levels of physical activity among urban children compared to their rural counterparts.[11,12] These results suggest that there may be gender and urban/rural disparities in physical activity levels among Tunisian children. Efforts to promote physical activity among children should consider these differences and target interventions to address specific barriers faced by different groups.

We found that 81% of Tunisian children met the recommended sleep duration of 10–13 h per day. When compared to other studies conducted in different countries, this percentage is higher than China (29.50%),[24] Sweden (62.50%),[21] and Bangladesh (59.70%)[22] and Finland (75.70%),[28] but lower than Canada (83.90%),[5] Australia (88.70%)[7] and Belgium (94%).[29] Adequate sleep is important for children's physical and mental health, as it supports healthy growth and development, cognitive function, and emotional well-being. Insufficient sleep, on the other hand, has been linked to a range of negative health outcomes, including obesity, impaired immune function, and poor academic performance.[30] The differences in the proportion of children meeting the recommended sleep duration could be influenced by a range of factors, such as cultural attitudes towards sleep, socioeconomic status, access to technology, and school schedules. Insufficient sleep, poor sleep quality, and irregular sleep schedules may affect children's physical health, cognitive capacity, socioemotional processes, and behavioral functioning, with implications for children's development and well-being. Family context and factors, confounded with cultural variables, play a critical role in children's sleep behavior and practices.[31]

Boys living in urban areas showing a lesser percentage (84.9%) of 10–13 h/day of sleep, in comparison to those living in rural areas (94.1%). Besides, the results indicated that 78.1% of preschool girls living in urban areas met the recommended sleep duration. While 71.4% of girls living in rural areas met the recommended sleep duration. In our opinion. This difference could be due to a number of factors, including family and cultural practices, access to technology, and socioeconomic status.

Boys living in rural areas scored higher in Working Memory than those living in urban areas ($p = 0.010$). However, there was no significant difference in Inhibition scores between boys living in these two different areas ($p = 0.424$). The girls showed no significant difference in Inhibition and Working Memory scores between urban and rural settings. It is important to note that the results of this study may be influenced by various factors, such as the quality of the physical and social environment in which children live, as well as access to resources and activities.

4.2. Feasibility of the SUNRISE protocol in a tunisian

The SUNRISE study in Tunisia is a significant contribution to this field, as it is the first study to use a comprehensive battery of tests to measure both gross and fine motor skills in this population. The tests used in this study cover a wide range of motor abilities, including lower body strength and mobility, posture, upper body strength, manipulation, functional mobility, postural stability, and dexterity. By using these tests, the researchers aim to gain a better understanding of the motor skills of the participants and their link to physical health and overall well-being. The results of this study reveal that boys living in urban areas have a significantly lower functional mobility time in seconds than boys living in rural areas. Girls in the two groups (urban and rural) show significantly different levels of postural stability, lower body strength, upper body strength, and dexterity. Observed differences in levels of postural stability, lower body strength, upper body strength and dexterity between girls living in different regions can be explained by differences in access to resources, active lifestyles, socio-economic factors and cultural influence.

There was very good compliance with the ActiGraph protocol, with 79.5% of participants providing at least 24 h of valid data. This is a positive finding as it indicates that most children were able to wear the accelerometer for the required period and that the data collected are likely to be representative of their physical activity and sleep patterns over the five-day period. Among these participants, we observe that 26 boys living in urban areas, 17 boys living in rural areas, 25 girls living in urban areas, and 21 girls living in rural areas provided valid data. It can be observed that both boys and girls living in rural areas provided 100% valid data, which is a very positive result. However, girls living in urban areas provided a weaker percentage of valid data (61%), which could indicate a difference in behavior or motivation towards physical activity or technology between girls in the two environments. Finally, the percentage of boys living in urban areas providing valid data is 79%, which is higher than that of girls living in urban areas. This could suggest that girls are less likely to comply with the ActiGraph protocol than boys, at least in an urban context.

There was very good compliance with the protocol, as indicated by the high proportion of children with valid accelerometer data (80% overall). This demonstrates that the majority of participants adhered to the requirements of wearing and utilizing the accelerometers. Among specific groups, such as RU boys and RU girls, the compliance rates were even higher, reaching 100%. Although there were slightly lower compliance rates among UR boys and UR girls, it is important to note that a significant portion of these groups still met the criteria for valid accelerometer data (79% and 61%, respectively). Furthermore, the completion rates for executive function tasks and the evaluation of gross and fine motor skills were excellent, with a 100% participation rate across all children and subgroup categories. Overall, these results demonstrate very good compliance with the protocol, indicating that the participants largely adhered to the study requirements and successfully completed the designated tasks and assessments.

4.3. Limitations

There is an urgent need to implement targeted actions to promote healthy behaviors among preschool-aged children in Tunisia. However, it is important to acknowledge the limitations of this research. The small sample size may limit the generalization of the findings to a larger population. Using a convenience sample may introduce potential biases, as it may not accurately represent the target population in a balanced manner. Collecting data only during the winter months (November to January) may not provide a comprehensive representation of the entire year or other seasonal periods. Thus, to better understand physical activity behaviors among preschoolers in Tunisia, further research with larger, representative samples and extended data collection periods is needed. Despite these limitations, prioritizing initiatives such as tailored school programs, inclusive community activities, and active parental involvement remains crucial for promoting active and healthy lifestyles among children, regardless of their gender or place of residence. To achieve this goal, schools and communities can organize educational workshops for parents on the benefits of physical activity and provide resources to help them encourage their children to be active. Additionally, public health initiatives in Tunisia should prioritize efforts to reduce children's screen time.

For community projects, we suggest organizing community sports leagues or clubs tailored to children, offering various activities such as soccer, basketball, or swimming, as well as creating outdoor play spaces

equipped with age-appropriate equipment. Regarding school programs, we recommend implementing physical activity breaks during school hours and integrating physical education classes into the curriculum. Concerning parental and community involvement, we propose workshops and informational sessions on the importance of physical activity, as well as collaborations with local stakeholders. Finally, technology integration can involve utilizing solutions such as activity trackers or mobile apps, as well as integrating educational resources and interactive media. These strategies aim to create environments conducive to increased physical activity and reduced sedentary behavior in children, ultimately contributing to their overall health and well-being.

To guide future research, it would be beneficial to delve deeper into the disparities in movement behaviors between children in urban and rural areas in Tunisia. More specific studies focusing on the socio-economic, environmental, and cultural determinants of these disparities could be undertaken. Additionally, longitudinal research could track the evolution of movement behaviors over time and assess the effectiveness of interventions. Furthermore, comparisons with other geographical and cultural contexts would provide additional insights. In summary, by enhancing our understanding of the factors influencing children's movement behaviors in Tunisia, we can better inform policies and interventions aimed at promoting their health and well-being.

5. Conclusions

This study aimed to assess the movement behaviors of preschool children over 24 h, to evaluate and compare the movement behaviors of preschool children in Tunisia and finally to compare the results between boys and girls living in urban and rural areas. Significant differences were observed in children's physical activity, sleep duration and BMI. Urban girls adhered more to the recommended sleep duration, while rural boys were more physically active. Urban boys spent more time in front of screens than rural boys, while urbain girls had less screen time. Girls and boys had different levels of postural stability, lower body strength, upper body strength, and dexterity. Improvements are needed to promote physical activity among Tunisian children, while reducing sedentary screen time should also be a priority. Initiatives including school programs, community activities and parental involvement can promote increased physical activity in children, regardless of gender or place of residence.

Ethical approval statement

All procedures were approved by the Ethics Committee of the Faculty of Medicine of Sousse (CEFMS 121/2022). Written informed parental consent, and participants' assent were obtained prior to commencement of study. All participants and their parents/legal representatives were fully informed about the protocol and its potential risks and benefits.

CRediT authorship contribution statement

Mohamed Amine Ltifi: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Olfa Turki:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Ghaith Ben-Bouzaiene:** Writing – review & editing, Writing – original draft, Validation, Project administration, Investigation, Data curation, Conceptualization. **Kar Hau Chong:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation. **Anthony D. Okely:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Mohamed Souhaiel Chelly:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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