

## Original article

# Associations between meeting 24-hour movement guidelines and quality of life among children and adolescents with autism spectrum disorder

Chuidan Kong<sup>a,\*,§</sup>, Aiguo Chen<sup>b,\*,§</sup>, Sebastian Ludyga<sup>c</sup>, Fabian Herold<sup>d</sup>, Sean Healy<sup>e</sup>,  
Mengxian Zhao<sup>a</sup>, Alyx Taylor<sup>f</sup>, Notger G. Müller<sup>d,g,h</sup>, Arthur F. Kramer<sup>i,j</sup>, Sitong Chen<sup>k</sup>,  
Mark S. Tremblay<sup>l,m</sup>, Liye Zou<sup>a,\*</sup>

<sup>a</sup> Body-Brain-Mind Laboratory, School of Psychology, Shenzhen University, Shenzhen 518061, China

<sup>b</sup> College of Physical Education, Yanzhou University, Yangzhou 225009, China

<sup>c</sup> Department of Sport, Exercise and Health, University of Basel, Basel 4052, Switzerland

<sup>d</sup> Research Group Degenerative and Chronic Diseases, Movement, Faculty of Health Sciences Brandenburg, University of Potsdam, Potsdam 14476, Germany

<sup>e</sup> Community Health Academic Group, School of Nursing, Psychotherapy and Community Health, Dublin City University, Dublin 9, Ireland

<sup>f</sup> School of Rehabilitation, Sport and Psychology, AECC University College, Bournemouth, BH5 2DF, UK

<sup>g</sup> Research Group Neuroprotection, German Center for Neurodegenerative Diseases (DZNE), Magdeburg 39120, Germany

<sup>h</sup> Center for Behavioral Brain Sciences (CBBS), Magdeburg 39118, Germany

<sup>i</sup> Center for Cognitive and Brain Health, Northeastern University, Boston, MA 02115, USA

<sup>j</sup> Beckman Institute, University of Illinois at Urbana-Champaign, Champaign, IL 61820, USA

<sup>k</sup> Institute for Health and Sport, Victoria University, Melbourne 8001, Australia

<sup>l</sup> Healthy Active Living and Obesity Research Group, CHEO Research Institute, Ottawa, Ontario K1H8L1, Canada

<sup>m</sup> Department of Pediatrics, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada

Received 2 June 2022; revised 4 July 2022; accepted 18 July 2022

Available online xxx

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## Abstract

**Background:** The Canadian 24-hour movement behavior (24-HMB) guidelines suggest that a limited amount of screen time use, an adequate level of physical activity (PA), and sufficient sleep duration are beneficial for ensuring and optimizing the health and quality of life (QoL) of children and adolescents. However, this topic has yet to be examined for children and adolescents with autism spectrum disorder (ASD) specifically. The aim of this cross-sectional observational study was to examine the associations between meeting 24-HMB guidelines and several QoL-related indicators among a national sample of American children and adolescents with ASD.

**Methods:** Data were taken from the 2020 National Survey of Children's Health dataset. Participants (n = 956) aged 6–17 years and currently diagnosed with ASD were included. The exposure of interest was adherence to the 24-HMB guidelines. Outcomes were QoL indicators, including learning interest/curiosity, repeating grades, adaptive ability, victimization by bullying, and behavioral problems. Categorical variables were described with unweighted sample counts and weighted percentages. Age, sex, race, preterm birth status, medication, behavioral treatment, household poverty level, and the educational level of the primary caregivers were included as covariates. Odds ratio (OR) and 95% confidence interval (95%CI) were used to present the strength of association between adherence to 24-HMB guidelines and QoL-related indicators.

**Results:** Overall, 452 participants (45.34%) met 1 of the 3 recommendations, 216 (22.65%) met 2 recommendations, whereas only 39 participants (5.04%) met all 3 recommendations. Compared with meeting none of the recommendations, meeting both sleep duration and PA recommendations (OR = 3.92, 95%CI: 1.63–9.48,  $p < 0.001$ ) or all 3 recommendations (OR = 2.11, 95%CI: 1.03–4.35,  $p = 0.04$ ) was associated with higher odds of showing learning interest/curiosity. Meeting both screen time and PA recommendations (OR = 0.15, 95%CI: 0.04–0.61,  $p < 0.05$ ) or both sleep duration and PA recommendations (OR = 0.24, 95%CI: 0.07–0.87,  $p < 0.05$ ) was associated with lower odds of repeating any grades. With respect to adaptive ability, participants who met only the PA recommendation of the 24-HMB were less likely to have difficulties dressing or bathing (OR = 0.11, 95%CI: 0.02–0.66,  $p < 0.05$ ) than those who did not. For participants who met all 3 recommendations (OR = 0.38, 95%CI: 0.15–0.99,  $p = 0.05$ ), the odds of being victimized by bullying was lower. Participants who adhered to both sleep duration

Peer review under responsibility of Shanghai University of Sport.

\*Corresponding author.

E-mail address: [liyezou123@gmail.com](mailto:liyezou123@gmail.com) (L. Zou).

§ These two authors contributed equally to this manuscript.

<https://doi.org/10.1016/j.jshs.2022.08.003>

and PA recommendations were less likely to present with severe behavioral problems (OR = 0.17, 95%CI: 0.04–0.71,  $p < 0.05$ ) than those who did not meet those guidelines.

**Conclusion:** Significant associations were found between adhering to 24-HMB guidelines and selected QoL indicators. These findings highlight the importance of maintaining a healthy lifestyle as a key factor in promoting and preserving the QoL of children with ASD.

**Keywords:** 24-hour movement guidelines; Autism spectrum disorder; Physical activity; Quality of life

## 1. Introduction

Autism spectrum disorder (ASD) is a heterogeneous neurodevelopmental condition<sup>1</sup> characterized by social interaction impairments, language and communication deficits, and repetitive patterns of activity, behaviors, and interests.<sup>2</sup> ASD is estimated to affect 1 in 132 individuals globally<sup>3</sup> and is more common in males than in females.<sup>1</sup> Recently, interventions for individuals with ASD have shifted from focusing on symptom alleviation to improving general well-being and quality of life (QoL).<sup>1</sup> QoL is an integrated construct used to evaluate subjective and objective well-being in several domains, such as physical health, mental well-being, social relationships, development and activities.<sup>4</sup> Instead of targeting a narrow range of outcomes, measuring QoL for individuals with ASD has emphasized the overall improvement on issues of considerable significance in daily life. Moreover, QoL also implies active research participation as far as responding to the interests and preferences of individuals with ASD and trying to promote their well-being.<sup>1</sup>

Previous studies have indicated that individuals with ASD experience a reduced QoL compared to their neurotypical peers.<sup>5–7</sup> Both contextual and individual factors, including inclusion in school activities, adaptive behaviors, social impairment, behavioral problems, and severity of ASD, are associated with QoL among children with ASD.<sup>5,8</sup> For instance, QoL-related dimensions development and activity are concerned with whether children and adolescents with ASD are able to independently perform learning activities and obtain good grades at school.<sup>5,9</sup> Adaptive behaviors, which refer to the ability to perform age-appropriate skills and daily tasks and to deal with real-life situations,<sup>10</sup> is associated with QoL in children with ASD. Children with ASD who have higher levels of adaptive behaviors reported better QoL,<sup>11</sup> while social impairment was shown to adversely affect QoL.<sup>12</sup> Further, studies indicate that individuals with ASD are more likely to be rejected and bullied by their neurotypical peers.<sup>13</sup> Behavioral problems might reduce QoL in children with ASD, a pattern that has been shown to persist into adulthood.<sup>14,15</sup> In general, children with ASD show lower QoL compared to their neurotypical peers, and limited studies have been conducted to investigate factors that might have a positive influence on QoL. This lack of knowledge impedes efforts to improve QoL among children with ASD. Therefore, examinations of the modifiable determinants of QoL among children with ASD are required from the research community.

Lifestyle plays an important role in the well-being (or QoL) of children with ASD. There is some evidence that lifestyle interventions—for instance, the regularity of physical activity

(PA)—can potentially be a promising factor in improving the QoL among children with ASD.<sup>16</sup> For example, an increase in the level of regular PA can improve social functioning<sup>16–18</sup> and cognitive performance in children with ASD.<sup>19–21</sup> Alternatively, unhealthy lifestyle behaviors (sedentary behavior (SB) and insufficient sleep) are adversely related to the well-being of individuals with ASD. For instance, inadequate sleep duration is associated with a greater possibility of reporting social skills deficits,<sup>22</sup> communication impairments, and repetitive patterns of activities and behaviors.<sup>23</sup> Longer screen time (sitting duration) is associated with higher odds of being diagnosed with ASD<sup>24</sup> as well as with poor cognitive and social skills,<sup>25</sup> which could directly reduce an individual's QoL. A focus on lifestyle interventions for improving QoL among children with ASD may be particularly warranted as children with ASD are known to engage in poorer health behaviors, including low levels of PA, high levels of SB, and inadequate sleep patterns.<sup>26–29</sup>

Traditionally, the influence of movement behaviors (including PA, SB, and sleep) on QoL was studied in isolation but not investigated collectively.<sup>30</sup> However, recently researchers have advocated for a more holistic perspective on the influence of movement behaviors, assessing combinations of PA, SB, and sleep on QoL-related outcomes as outlined in the Canadian 24-Hour Movement Guidelines (24-HMB).<sup>31–33</sup> Researchers are beginning to recognize that these 3 movement behaviors are co-dependent and should be considered concurrently, as these 3 behaviors are mutually exclusive and time constrained, meaning time spent on 1 behavior necessarily displaces time spent on at least 1 of the remaining movement behaviors.<sup>31–33</sup> The 24-HMB guidelines were developed in response to the recognition of this co-dependence between PA, SB, and sleep, and there is now substantial evidence that meeting the recommendations outlined in those guidelines has a positive influence on QoL-related outcomes, at least in neurotypical children.<sup>31–33</sup>

To date, the relationship between 24-HMB guideline adherence and QoL in children with ASD has, to the best of our knowledge, not been examined. Given the evidence that (a) children with ASD generally have lower levels of PA, higher levels of SB, and poorer sleep health compared to neurotypical children<sup>22,28,34,35</sup>; (b) the effects of movement behaviors on QoL indicators in children and adolescents with ASD have not been investigated yet<sup>1</sup>; and (c) meeting the guidelines concerning all movement behaviors might have synergistic effects, the investigation of associations between 24-HMB and QoL-related indicators in children and adolescents with ASD is a critical area for future research. In addition, previous studies

reported that demographic factors (e.g., sex or gender), socio-demographic factors (e.g., family support), ASD symptoms severity, and ASD-related treatments were observed to be associated with the QoL of individuals with ASD.<sup>5,36,37</sup> Accordingly, these covariates should be taken into account during analysis for greater accuracy and reliability of results obtained.

The present study examined the associations between meeting 24-HMB guidelines and several QoL indicators in children with ASD. Specifically, we hypothesized that meeting 24-HMB guidelines would predict better performance in several QoL-related indicators after controlling for demographic, socioeconomic, and other factors (i.e., age, sex, race, preterm birth status, overweight status, highest educational level of parents, household poverty level), ASD severity (mild or moderate and severe), and ASD-related interventions (i.e., ASD medication and ASD behavioral treatment).

## 2. Methods

### 2.1. Study design and participants

This cross-sectional study used data from the U.S. National Survey of Children's Health (2020 NSCH), which were collected from June 2020 to January 2022.<sup>38</sup> This survey has been conducted annually since 2016. It is supported by the Health Resources and Services Administration's Maternal and Child Health Bureau and the U.S. Census Bureau, and it aims to assess the health status of American children at both the national and state levels. In the context of this annual survey, data are collected on health-related measures of the children, their families, and communities, the prevalence of disease type, and associated health care needs. The survey design and its procedures are presented publicly and are described in more detail in the documents available on the following website: <https://www.census.gov/programs-surveys/nsch/data/datasets.html>.<sup>38</sup>

In brief, the 2020 NSCH sampled approximately 240,000 addresses, covering all 50 states and the District of Columbia, to participate in its first-stage screener questionnaire, which collects information on the presence of children within the household in order to proceed with selection of eligible households.<sup>38</sup> Screener questionnaires were initially completed by 93,500 households, and 51,107 of them were eligible to continue with the topical questionnaire. Of these 51,107 households, 42,777 provided complete responses with regard to the assessed outcome measures. Respondents, who are primary caregivers of the child in the household, can choose web, paper, telephone, or email to respond to the survey and ask for assistance.

In the present study, data from children aged 6–17 years who were currently diagnosed with ASD ( $n = 1030$ ) were included. To determine the eligibility of a child, the 2 following criteria needed to be met (as reported by the primary caregivers of the child): (a) "Has a doctor or other health care provider ever told you that this child has ASD (including Asperger's disorder or pervasive developmental disorder)?" and (b) "If yes, does the child currently have the condition?"

### 2.2. Demographic and medical information

Age, sex, ethnicity, preterm birth status, overweight status, ASD-related medication and behavioral treatment, household poverty level, and the highest level of education of primary caregivers were used in this study as covariates (Table 1). Family income was coded into 2 categories according to the federal poverty level. Participants' overweight status was defined by caregiver-reported diagnosis from a doctor or health care provider.

### 2.3. Dependent variables: QoL-related indicators

#### 2.3.1. Learning interest/curiosity

Learning (interest/curiosity) was operationalized using the following questions: (a) "How often does this child show interest and curiosity in learning new things?" (1 = always to 4 = never); and, (b) "Since starting kindergarten, has this child repeated any grades?" (0 = no and 1 = yes). Scores on frequency responses were reversed, with higher points reflecting better performance with respect to learning interest/curiosity. In addition, a binary response was recorded as 0 = no and 1 = yes.

#### 2.3.2. Adaptive ability

Adaptive ability, which refers to the ability to perform age-appropriate skills and daily tasks and to deal with real-life situations,<sup>10</sup> was measured using a single-item question: "Does your child have any difficulties concerning dressing or bathing?" (0 = no and 1 = yes).

#### 2.3.3. Victimization by bullying

A single-item question was used to measure the frequency of being bullied: "How often during the past 12 months was your child bullied, picked on, or excluded by other children?" (1 = never to 5 = almost every day). Higher scores indicate more severe problems in terms of victimization by being bullied.

#### 2.3.4. Behavioral problems

Behavioral or conduct problems in childhood are characterized by serious violations of rules, patterns of violent behaviors, and aggression toward others.<sup>39</sup> In the current study, behavioral problems were measured using the following questions: (a) "Has a doctor, other health care provider, or educator ever told you that your child has behavioral or conduct problems?" and (b) "If yes, does this child currently have the condition?" The answer to this question was scored on a severity-related 3-point rating scale (1 = mild to 3 = severe). Scores on severity- or frequency-related responses were reversed, with higher points reflecting lower social interaction. In addition, a binary response was recorded as 0 = no and 1 = yes, respectively.

#### 2.3.5. Exposures of interest

The current study used adherence to 24-HMB as the exposures of interest. Adherence to 24-HMB guidelines was handled in terms of continuous (0 vs. 1 vs. 2 vs. 3) and categorical

Table 1  
Participant characteristics ( $n = 956$ ).

Characteristics	Value <sup>a</sup>
Age (years)	11.98 $\pm$ 3.81
Sex	
Male	759 (78.61)
Female	197 (21.39)
Ethnicity	
White	751 (69.73)
Black or African American	65 (15.11)
American Indian/Alaska native	6 (0.37)
Asian	37 (2.89)
Native Hawaiian and other Pacific Islander	6 (1.83)
Two or more races	91 (10.07)
Born $\geq 3$ weeks before due date	
Yes	151 (17.66)
No	805 (82.34)
Overweight status	
Yes	180 (16.75)
No	776 (83.25)
ASD severity	
Mild	484 (44.04)
Moderate or severe	472 (55.96)
ASD-related medication or treatment	
Behavioral treatment only	327 (34.53)
Medication only	62 (5.13)
Behavioral treatment and medication	204 (23.13)
Neither	352 (37.21)
Household poverty level	
$\leq 0\%$ –99% federal poverty level	137 (16.39)
$\geq 100\%$ federal poverty level	819 (83.61)
Highest education level of primary caregivers	
Less than high school	23 (6.00)
High school	155 (20.27)
Some college credit or associated degree (AA, AS)	260 (25.61)
College degree or higher	518 (48.12)
Adherence to the 24-hour movement guidelines	
None	249 (26.97)
Meeting 1 out of 3	452 (45.34)
Screen time	86 (9.94)
Sleep	328 (29.77)
Physical activity	38 (5.63)
Meeting 2 out of 3	216 (22.65)
Screen time + Sleep	136 (12.52)
Screen time + Physical activity	39 (4.37)
Sleep + Physical activity	41 (5.76)
All	39 (5.04)
Behavioral problems (severity)	
Mild	184 (32.78)
Moderate	298 (50.74)
Serious	74 (16.48)
Repeated any grades	
Yes	138 (15.97)
No	818 (84.03)
Being bullied	
Never	322 (40.83)
1–2 times in the past 1 year	277 (27.99)
1–2 times per month	131 (10.69)
1–2 times per week	111 (11.24)
—Almost every day	115 (9.25)
Show interest and curiosity	
Always	249 (26.37)
Usually	328 (31.76)
Sometimes	337 (37.59)
Never	42 (4.28)

(continued on next page)

Table 1 (Continued)

Characteristics	Value <sup>a</sup>
Difficulty dressing or bathing	
Yes	184 (18.30)
No	769 (81.70)

<sup>a</sup> Values are mean  $\pm$  standard deviation or  $n$  (weighted (wt) percentages);  $n$  represents unweighted sample counts, and wt% is weighted sample sizes.

Abbreviation: ASD = autism spectrum disorder.

variables (the combinations of guidelines met). More specifically, the results of 24-HMB guidelines as categorical variables were reported as (a) meeting 1 of 3 (PA, SB, Sleep), (b) meeting 2 of 3 (PA and SB, PA and Sleep, SB and Sleep), and (c) meeting all guidelines. In the Canadian 24-HMB for children and youth,<sup>33</sup> the following recommendations were used: (a) a sleep duration of 9–11 h for children aged 5–13 years and 8–10 h for adolescents aged 14–17 years, (b) children and adolescents accumulate at least 60 min of moderate-to-vigorous PA per day, and (c) recreational screen time should be limited to no more than 2 h per day.<sup>31</sup>

The 3 components (PA, screen time, and sleep duration) of 24-HMB were measured using 3 single-item questions. Participants who met or did not meet the 24-HMB guidelines were coded as 1 or 0, respectively. PA level was measured using the question, “During the past week, on how many days did this child exercise, play a sport, or participate in PA for at least 60 minutes?” This question was scored on a day-related four-point rating scale (1 = 0 days, 2 = 1–3 days, 3 = 4–6 days, and 4 = 7 days/every day). Participants who chose option 4 (7 days/every) were coded as 1 and the rest were coded as 0. Sleep duration was quantified with the question, “During the past week, how many hours of sleep did this child get on most weeknights?” Responses were scored on a seven-point scale (1 = less than 6 hours, 2 = 6 hours, 3 = 7 hours, 4 = 8 hours, 5 = 9 hours, 6 = 10 hours, and 7 = 11 hours or more). For children aged 5–13 years, responses of 5–7 (9 h or above) were considered meeting the guideline, and responses of 4–7 (8 hours or above) were also treated as meeting the sleep guideline for participants aged 14–17 years. Screen time (as a commonly used proxy for SB) was measured with the question, “On most weekdays, about how much time did this child spend in front of a TV, computer, cell phone, or other electronic device watching programs, playing games, accessing the internet, or using social media? (Do not include time spent doing schoolwork.)” The responses were scored on a five-point rating scale (1 = less than 1 h, 2 = 1 h, 3 = 2 h, 4 = 3 h, and 5 = 4 or more). Responses from 1 to 3 (no more than 2 h) were coded as 1 and the rest of the responses were coded as 0.

#### 2.4. Statistical analysis

The statistical analyses were conducted using Stata (Stata-Corp, College Station, TX, USA). A new variable, STRATA-CROSS, was created with the variance state of residence (FIPSST), identifier for households flagged with children (STRATUM), and unique household identifier in order to



apply sampling weights. Sub-populations were determined with the option of survey data in Stata for children and adolescents diagnosed with ASD. Descriptive statistics were calculated for all variables. Continuous variables were described with means and standard deviations. Categorical variables were described with unweighted sample counts and weighted (wt) percentages. Multivariable logistic regressions were used to estimate the odds ratios (OR), with 95% confidence interval (95%CI), between adherence to 24-HMB guidelines and QoL-related indicators (e.g., showing interest and curiosity in learning, repeating grades, difficulty dressing/bathing, victimization by bullying, behavioral problems). The number of guideline recommendations met (continuous variables) and the combinations of guideline recommendations (categorical variables) were separately treated as the independent variables in the models. Age, sex, race, preterm birth status, ASD medication, ASD behavioral treatment, household poverty level, and the highest level of education of the primary caregivers of the child were included as covariates. For all statistical tests, the significance level was set at  $\alpha \leq 0.05$ .

### 3. Results

#### 3.1. Sample characteristics

This study included American children and adolescents with ASD ( $n = 1030$ , weighted population size = 1,269,760) who were between 6 and 17 years. After the removal of participants with invalid responses ( $n = 74$ ), data on 956 participants remained for analysis. The age of the sample participants was  $11.98 \pm 3.81$  years (mean  $\pm$  standard deviation), 78.61% of children and adolescents with ASD were male, and the majority identified as White (69.73%). About one-fifth of the children and adolescents included in this study were born preterm (i.e., 3 weeks or more before the expected birth date), and approximately 16.75% were overweight. Around 44% of the sample had mild ASD symptoms, and approximately 40% were not currently receiving ASD-related medication or treatment. Only a small proportion of participants (16.39%) were between 0% and 99% of the federal poverty level, and only a small proportion of the primary caregivers of the children or adolescents (6.00%) responded that they had not completed high school (Table 1).

#### 3.2. Adherence to the 24-HMB

Overall, weighted 9.94% ( $n = 86$ ), weighted 29.77% ( $n = 328$ ), and weighted 5.63% ( $n = 38$ ) of participants met only the screen time recommendation, only the sleep duration recommendation, or only the PA recommendation, respectively. Around a quarter of participants ( $n = 249$ , wt% = 26.97) met none of the 3 movement guideline recommendations, whereas only a small proportion ( $n = 39$ , wt% = 5.04) adhered to all 3 components of the 24-HMB guidelines. For those participants who met 2 of the 3 24-HMB guideline recommendations ( $n = 216$ , wt% = 22.65), the majority adhered to the recommendations concerning screen time and sleep ( $n = 136$ , wt% = 12.52) (Table 1).

#### 3.3. Associations between meeting 24-HMB and school development

##### 3.3.1. Showing interest and curiosity in learning

The odds of showing learning interest and curiosity for those who met sleep duration and PA recommendations (OR = 3.92, 95%CI: 1.63–9.48,  $p < 0.01$ ) or for those who met all 3 24-HMB guideline recommendations (OR = 2.11, 95%CI: 1.03–4.35,  $p < 0.05$ ) were significantly higher than they were for those who met none of the 24-HMB guidelines. Household poverty level was the only socioeconomic factor that showed a significant relationship as children and adolescents in households between 100% and 400% of the federal poverty level (OR = 2.35, 95%CI: 1.28–4.34,  $p < 0.05$ ) were more likely to show interest and curiosity in learning when compared with those in households between 0% and 99% of the federal poverty level (Table 2).

##### 3.3.2. Repeat any grades

Table 3 shows the association between meeting the 24-HMB guidelines and repeating any grades. There was no significant association between the number of guideline recommendations met and this outcome. Compared with meeting none of the 24-HMB recommendations, meeting only the PA recommendation increased the odds of repeating grades (OR = 3.55, 95%CI: 1.15–10.99,  $p < 0.05$ ) while meeting either screen time or sleep time with PA recommendations showed smaller odds of repeating any grades (OR = 0.15, 95%CI: 0.04–0.61,  $p < 0.05$  and OR = 0.24, 95%CI: 0.07–0.87,  $p < 0.05$ , respectively). Both multivariable models provide evidence that participants with moderate or severe ASD symptoms were more likely to repeat grades (OR = 2.60, 95%CI: 1.41–4.80,  $p < 0.01$  and OR = 2.77, 95%CI: 1.51–5.09,  $p < 0.05$ , respectively).

Meeting the PA recommendation of the 24-HMB guidelines was significantly associated with lower odds of having difficulties dressing or bathing (OR = 0.11, 95%CI: 0.02–0.66,  $p < 0.05$ ). Compared to participants with mild ASD symptoms, both multivariable models show that those with moderate or severe symptoms were less efficient at dressing and bathing themselves (Model 1: OR = 4.82, 95%CI: 2.56–9.07,  $p < 0.01$ ; Model 2: OR = 4.99, 95%CI: 2.62–9.50,  $p < 0.01$ ). Participants who received only behavioral treatment were more likely to display difficulties dressing and bathing (OR = 2.08, 95%CI: 1.02–4.25,  $p < 0.05$ ). Adolescents (OR = 0.49, 95%CI: 0.26–0.94,  $p < 0.05$ ) were less likely than children to show difficulties dressing and bathing, while being overweight was associated with higher odds of having difficulties with those same activities (Model 1: OR = 2.33, 95%CI: 1.17–4.65,  $p < 0.05$ ; Model 2: OR = 2.39, 95%CI: 1.20–4.73,  $p < 0.05$ ) (Table 4).

#### 3.4. Associations between meeting 24-HMB and victimization by bullying

Meeting all 3 recommendations of the 24-HMB guidelines was associated with being bullied (OR = 0.38, 95%CI: 0.15–0.99,  $p = 0.05$ ). No significant associations between

Table 2  
Meeting 24-hour movement guidelines and the frequency of showing interest and curiosity in learning (school development).

Show interest and curiosity in learning	Model 1: Meeting 24-hour movement guidelines as continuous variable		Model 2: Meeting 24-hour movement guidelines as categorical variable	
	Odds ratio (95%CI)	<i>p</i>	Odds ratio (95%CI)	<i>p</i>
Age, years				
6–13 (reference)	Reference group			
14–17	0.74 (0.49–1.11)	0.15	0.81 (0.54–1.23)	0.33
Sex				
Male (reference)	1 (reference)	N/A	1 (reference)	N/A
Female	0.99 (0.60–1.61)	0.94	0.95 (0.59–1.54)	0.83
Overweight				
No (reference)	1 (reference)	N/A	1 (reference)	N/A
Yes	0.96 (0.59–1.58)	0.88	1.01 (0.62–1.64)	0.97
Ethnicity				
White (reference)	1 (reference)	N/A	1 (reference)	N/A
Black/African American	1.66 (0.91–3.04)	0.09	1.38 (0.77–2.48)	0.28
American Indian/Alaska native	1.09 (0.57–2.07)	0.83	1.29 (0.63–2.64)	0.48
Asian	0.68 (0.36–1.29)	0.21	0.47 (0.22–1.01)	0.05
Native Hawaiian and other Pacific Islander	0.28 (0.05–1.69)	0.17	0.24 (0.04–1.60)	0.14
Two or more races	0.74 (0.35–1.55)	0.42	0.86(0.43–1.73)	0.68
Born $\geq 3$ weeks before due date				
No (reference)	1 (reference)	N/A	1 (reference)	N/A
Yes	1.12 (0.66–1.90)	0.70	0.94 (0.55–1.59)	0.80
ASD severity level				
Mild (reference)	1 (reference)	N/A	1 (reference)	N/A
Moderate and severe	0.56 (0.36–0.87)	0.01*	0.57 (0.37–0.88)	0.01*
ASD medication and behavioral treatment				
Neither behavioral treatment nor medication (reference)	1 (reference)	N/A	1 (reference)	N/A
Behavioral treatment and medication	0.66 (0.36–1.22)	0.19	0.64 (0.35–1.16)	0.14
Behavioral treatment only	0.73 (0.47–1.16)	0.19	0.72 (0.46–1.14)	0.17
Medication only	0.58 (0.18–1.89)	0.37	0.44 (0.13–1.45)	0.18
Household poverty level (Federal Poverty Level)				
0%–99% (reference)	1 (reference)	N/A	1 (reference)	N/A
100%–400%	2.30 (1.27–4.14)	0.01*	2.35 (1.28–4.34)	0.01*
Highest level of education of primary caregivers				
Less than high school (reference)	1 (reference)	N/A	1 (reference)	N/A
High school	0.43 (0.15–1.25)	0.12	0.46 (0.15–1.37)	0.16
Some college credit or associated degree	0.75 (0.27–2.12)	0.59	0.79 (0.27–2.35)	0.68
College degree or higher	0.70 (0.25–1.94)	0.49	0.78 (0.27–2.31)	0.66
Guidelines met (continuous)	1.22 (0.97–1.53)	0.10	/	/
Guidelines met (categorical)				
None (reference)	/	/	1 (reference)	N/A
Screen time only	/	/	1.15 (0.48–2.74)	0.76
Sleep only	/	/	0.81 (0.46–1.43)	0.47
Physical activity only	/	/	0.98 (0.51–1.90)	0.96
Screen time + Sleep	/	/	1.03 (0.52–2.04)	0.94
Screen time + Physical activity	/	/	0.56 (0.15–2.08)	0.39
Sleep + Physical activity	/	/	3.92 (1.63–9.48)	0.002**
All 3	/	/	2.11 (1.03–4.35)	0.04*
Prob > $F^a$	0.001		<0.001	

<sup>a</sup> Means overall model  $F$  statistic; \*  $p < 0.05$ .

\*\*  $p < 0.01$ .

Abbreviations: 95%CI = 95% confidence interval; ASD = autism spectrum disorder; FPL = federal poverty level; N/A = Not applicable; Prob = Probability.

meeting subsets of the guidelines (e.g., meeting <3 guideline recommendations) and frequency of being bullied were identified. In both multivariable models, severity of ASD was positively associated with victimization by bullying (Model 1: OR = 1.69, 95%CI: 1.14–2.52,  $p < 0.05$ ; Model 2: OR = 1.78, 95%CI: 1.19–2.66,  $p < 0.05$ ). Compared with receiving no interventions, participants who received both behavioral treatment and medication(s) showed higher odds of being bullied

(Model 1: OR = 2.11, 95%CI: 1.18–3.77,  $p < 0.05$ ; Model 2: OR = 2.11, 95%CI: 1.21–3.70,  $p < 0.05$ ). With respect to demographic factors, adolescents (aged 14–17 years) (OR = 0.61, 95%CI: 0.38–0.97,  $p < 0.05$ ) were more likely to be bullied than children (aged 6–13 years). African American participants were less likely to be bullied (Model 1: OR = 0.40, 95%CI: 0.20–0.80,  $p < 0.05$ ; Model 2: OR = 0.42, 95%CI: 0.21–0.84,  $p < 0.05$ ). Higher educational levels of primary

caregivers (i.e., associate college degree and college degree or higher) were associated with victimization of children or adolescents by bullying (Table 5).

### 3.5. Associations between meeting 24-HMB and behavioral problems

Table 6 shows the associations between meeting 24-HMB guidelines and the severity of behavioral problems. Compared with meeting none of the 24-HMB guideline recommendations, meeting both the recommendations concerning sleep duration and PA was associated with lower odds of having more severe behavioral problems (OR = 0.17, 95%CI: 0.04–0.71,  $p < 0.05$ ). In both multivariable models, we observed evidence that participants with moderate and severe ASD symptoms were more likely to repeat grades (OR = 6.51, 95%CI: 3.34–12.72,  $p < 0.01$  and OR = 6.72, 95%CI: 3.38–13.36,  $p < 0.01$ , respectively). American Indian/Alaska native participants showed higher odds of encountering behavioral problems (Model 1: OR = 7.34, 95%CI: 2.70–19.94,  $p < 0.01$ ; Model 2: OR = 11.90, 95%CI: 3.02–46.92,  $p < 0.01$ ). When the 24-HMB guideline recommendations as categorical variables were analyzed, participants ranging from 14 to 17 years displayed more severe behavioral problems than their counterparts aged 6 to 13 years (OR = 2.60, 95%CI: 1.28–5.30,  $p < 0.05$ ).

## 4. Discussion

This cross-sectional study examined the relationship between meeting the 24-HMB guidelines and QoL-related indicators in a nationally representative sample of U.S. children and adolescents with ASD. We observed that only a relatively limited number of children and adolescents with ASD adhered to all three 24-HMB guideline recommendations. Significant associations were found between meeting 1 or more 24-HMB recommendations and some of the examined outcomes (i.e., showing interest/curiosity, repeating of grades, difficulty dressing/bathing, being bullied, and the severity of behavioral problems). Our study responded to the appeal for research that aims to promote QoL among individuals with ASD.<sup>1</sup> Moreover, it extended the literature related to the 24-HMB framework as it broadens the current knowledge regarding the importance of movement behaviors on QoL among children and adolescents with ASD.

### 4.1. Adherence to 24-HMB

Of concern, only a small proportion of children and adolescents with ASD met all 3 guideline recommendations provided in the 24-HMB statement. This finding is consistent with prior studies.<sup>29,40–42</sup> For example, it was observed that only 6.54% of children and 4.38% of adolescents with ASD complied with all 3 guidelines.<sup>29</sup> Compliance with the PA recommendation corroborates the observation that, worldwide, the majority of adolescents do not meet current recommendations concerning PA.<sup>43</sup>

An unexpected finding of the current study was that meeting all 24-HMB guidelines was not significantly associated with several QoL-related outcomes. Instead, combinations of recommendations met, specifically sleep and PA recommendations, were more likely to be associated with beneficial results concerning QoL-related indicators. These results are supported by previous studies investigating associations between individual (isolated) components of the 24-HMB among individuals with ASD. For instance, regular engagement in PA was associated with reduced stereotypical behaviors and stress-related emotions as well as improved social interactions.<sup>44</sup> More specifically, a recent study investigated the association of PA (device-measured) with QoL among adults with ASD and intellectual disability, suggesting that daily step count was positively associated with QoL.<sup>45</sup> Thus, recommendations for PA for this unique group have been made in clinical settings.<sup>46</sup> Conversely, sleep problems (including sleep insufficiency and poor sleep quality) as an unhealthy lifestyle behavior have significantly contributed to reduced subjective QoL in individuals with ASD.<sup>47</sup> For example, shorter sleep duration was observed to be associated with poor QoL among children with ASD. These findings suggest that the 3 lifestyle behaviors might not be equally important for children and adolescents with ASD. Meeting specific combinations of 24-HMB recommendations rather than meeting all might also exert benefits for this group, although further experimental research is necessary to investigate this assumption in more detail. Studies using more robust measures of the 24-HMBs are required to further explore these findings.

### 4.2. Meeting 24-HMB and learning interest/curiosity

In general, showing interest and curiosity are important prerequisites for learning, an important QoL indicator for children.<sup>48</sup> We found that meeting sleep and PA recommendations or meeting all 3 guideline recommendations were related to better performance in this outcome. Although studies regarding the associations between 24-HMB guidelines and curiosity in learning are limited, a cross-sectional analysis of U.S. neurotypical children reported a positive association between the number of movement guideline recommendations met and global cognition,<sup>49</sup> which is related to curiosity for learning. In the current study, participants in wealthier households tended to display a more favorable interest in learning. This is consistent with previous work about general learning motivation.<sup>50</sup> Although socioeconomic factors did not show a direct relationship to learning motivation, they are associated with the family environment, which impacts children directly. Families with relatively higher socioeconomic status might be more likely to afford and provide a cognitively stimulating environment for their children (e.g., having lots of books, talking about political and social issues, going to lectures, plays, or concerts), which in turn can facilitate the curiosity of their children.<sup>50</sup>

Approximately 15% of our sample had repeated grades since attending kindergarten. It is interesting that our analysis revealed that meeting only the PA recommendation *increased* the odds of repeating grades, while meeting PA with the screen



time or sleep recommendation, in contrast, was associated with lower odds of repeating a grade. Daily PA, SB, and sleep are codependent, mutually exclusive, and time constrained (to 24-h). In other words, time spent on 1 behavior necessarily displaces time spent on at least one of the remaining behaviors. That is, emphasizing adherence to the MVPA (moderate-to-vigorous PA) guideline ( $\geq 1$  hour per day) can potentially displace time for academic study. Alternatively, care providers of children with more severe ASD symptoms or learning challenges may be more likely to have a lower academic expectation and lean on PA as an outlet for their child. Meeting 2 recommendations might help to balance the time spent in 3 aspects and imply that the beneficial impacts were attributable to meeting one of the sedentary or sleep recommendations in combination with PA. As expected, participants with severe ASD symptoms were more likely to repeat grades.

#### 4.3. Meeting 24-HMB and adaptive ability

We found that meeting only the PA recommendation was associated with lower odds of having difficulties dressing or bathing. As PA and adaptive ability are both related to motor development, those with better motor skills might take a more active part in PA,<sup>51,52</sup> which might in turn boost motor skills.<sup>53,54</sup> Additionally, we found that age group, overweight status, and ASD severity were significant factors associated with difficulties dressing and bathing. Younger, overweight participants and those with severe ASD symptoms were more likely to show difficulty dressing or bathing.

#### 4.4. Meeting 24-HMB and severity of being bullied (social interaction)

In accordance with prior literature,<sup>55</sup> we determined that children and adolescents with more severe ASD symptoms were more likely to show deficits in social interactions with peers. Given that social interaction deficit is 1 core symptom of ASD, it is not surprising that ASD severity is associated with more impairments in social communication skills and, thus, individuals with more severe ASD encounter greater challenges in social reciprocity in friendships. Another possible explanation is that individuals with milder ASD symptoms were less likely to engage in social interaction due to the heightened social awareness of relationships and greater concern about negative feedback towards them.<sup>56</sup> Age emerged as a significant predictor in the second logistic regression model, with adolescents less likely to be bullied than younger children. This pattern was consistent with the previous general bullying literature, in which it is reported that bullying decreases with advanced age.<sup>57</sup> We also observed that higher educational levels of primary caregivers predicted a higher risk of being bullied for their children. It is possible that care providers with higher educational levels are more occupied by their work and thus are less frequently engaged in their children's school settings. This interpretation is supported by evidence that, in children with ASD, low levels of parental engagement with respect to school have been found to be associated with increased bullying.<sup>58</sup> Furthermore, we noticed that

meeting all three 24-HMB guideline recommendations was associated with a lower frequency of being bullied. In light of the fact that the severity of ASD symptoms might influence compliance with the 24-HMB guidelines, individuals meeting all 3 guidelines were more likely to have better social function than those who did not meet any of the guidelines; thus, children and adolescents who meet the guidelines might have fewer behavioral difficulties in social interactions. However, to provide empirical evidence for the latter speculation, more research on the mechanisms related to the observed phenomenon is needed.<sup>1</sup>

#### 4.5. Meeting 24-HMB and behavioral problems

We observed that meeting the recommendations concerning sleep duration and PA were associated with less severe behavioral difficulties. In line with prior research, externalizing difficulties were one of the risk factors for being bullied among ASD children.<sup>58</sup> The severity level of ASD showed a positive association with the severity of behavioral problems. Similarly, the literature on developmental disability suggests that the severity of disability strongly increases the risk of behavioral problems.<sup>59</sup>

#### 4.6. Limitations and future directions

Although the current study observed some new and favorable associations between meeting 24-HMB recommendations and several QoL-related indicators, the cross-sectional design limits our insights into the bi-directional associations between adherence to 24-HMB guidelines and QoL-related indicators. The effectiveness of prescribing the 24-HMB guidelines as a lifestyle intervention for ASD individuals needs to be further examined in empirical studies. In the current study, the impact of meeting PA recommendations on several QoL-related indicators was inconsistent, indicating that duration, intensity, and type of PA (i.e., group activity vs. individual activity, endurance vs. strength) might be important in determining the pattern of relationships among children and adolescents with ASD. It is likely that children and adolescents with ASD would benefit from meeting the 24-HMB guidelines if more details of PA-related indicators were examined, as the health benefits of increased PA, moderated recreational screen time, and healthy sleep duration are unequivocal.<sup>31</sup>

A review on sleep correlates of pervasive developmental disorders found that sleep disturbance, including sleep resistance and disruptive nightmare awakenings, is a prevalent problem for this group.<sup>60</sup> Compared to their neurotypical peers (25%–40%), ASD individuals (40%–80%) are more likely to have sleep problems.<sup>27</sup> In the present study, we only used sleep duration to operationalize the sleep domain of the 24-HMB, as done in previous studies.<sup>29,31</sup> However, given the limitations of this approach, future studies should consider performing a more comprehensive assessment of sleep patterns in order to obtain a more nuanced understanding of whether different aspects of sleep (e.g., sleep duration or sleep quality) might influence QoL in children and adolescents with ASD differentially. In addition, the measurement of screen time in the



Table 3  
Meeting 24-hour movement guidelines and repeating any grades (school development).

Repeated any grades	Model 1: Meeting 24-hour movement guidelines as continuous variable		Model 2: Meeting 24-hour movement guidelines as categorical variable	
	Odds ratio (95%CI)	<i>p</i>	Odds ratio (95%CI)	<i>p</i>
Intercept	0.04 (0.002–0.50)	0.01	0.06 (0.01–0.46)	0.01
Age, years				
6–13 (reference)	1 (reference)	N/A	1 (reference)	N/A
14–17	1.05 (0.96–1.15)	0.30	1.01 (0.55–1.86)	0.99
Sex				
Male (reference)	1 (reference)	N/A	1 (reference)	N/A
Female	0.68 (0.30–1.56)	0.36	0.54 (0.25–1.16)	0.11
Overweight				
No (reference)	1 (reference)	N/A	1 (reference)	N/A
Yes	0.79 (0.30–1.64)	0.41	0.77 (0.32–1.81)	0.54
Ethnicity				
White (reference)	1 (reference)	N/A	1 (reference)	N/A
Black/African American	0.81 (0.34–1.93)	0.64	0.82 (0.32–2.05)	0.66
American Indian/Alaska native	18.74 (1.77–198.77)	0.02*	22.03 (2.36–205.22)	0.01*
Asian	0.50 (0.11–2.23)	0.36	0.43 (0.08–2.24)	0.31
Native Hawaiian and other Pacific Islander	1 (empty)	N/A	1 (empty)	N/A
Two or more races	0.60 (0.19–1.87)	0.42	0.62 (0.19–2.00)	0.43
Born $\geq 3$ weeks before due date				
No (reference)	1 (reference)	N/A	1 (reference)	N/A
Yes	1.32 (0.59–2.95)	0.51	1.27 (0.57–2.83)	0.56
ASD severity level				
Mild (reference)	1 (reference)	N/A	1 (reference)	N/A
Moderate and severe	2.60 (1.41–4.80)	0.002**	2.77 (1.51–5.09)	0.01*
ASD medication and behavioral treatment				
Neither behavioral treatment nor medication (reference)	1 (reference)	N/A	1 (reference)	N/A
Behavioral treatment and medication	1.67 (0.75–3.70)	0.21	1.88 (0.84–4.24)	0.13
Behavioral treatment only	0.66 (0.32–1.36)	0.26	0.54 (0.25–1.13)	0.10
Medication only	1.84 (0.57–5.86)	0.31	1.87 (0.68–5.13)	0.22
Household poverty level (Federal Poverty Level)				
0%–99% (reference)	1 (reference)	N/A	1 (reference)	N/A
100%–400%	0.51 (0.23–1.14)	0.11	0.53 (0.24–1.15)	0.11
Highest level of education of primary caregivers				
Less than high school (reference)	1 (reference)	N/A	1 (reference)	N/A
High school	1.91 (0.27–13.43)	0.51	2.05 (0.32–13.32)	0.45
Some college credit or associated degree	4.38 (0.61–31.54)	0.14	5.03 (0.82–30.87)	0.08
College degree or higher	2.83 (0.39–20.66)	0.31	3.38 (0.54–21.02)	0.19
Guidelines met (continuous)	1.03 (0.69–1.54)	0.87	/	/
Guidelines met (categorical)				
None (reference)	/	/	1 (reference)	N/A
Screen time only	/	/	0.66 (0.20–2.16)	0.49
Sleep only	/	/	1.05 (0.50–2.20)	0.89
Physical activity only	/	/	3.55 (1.15–10.99)	0.03*
Screen time + Sleep	/	/	0.67 (0.22–2.03)	0.48
Screen time + Physical activity	/	/	0.15 (0.04–0.61)	0.01*
Sleep + Physical activity	/	/	0.24 (0.07–0.87)	0.03*
All 3	/	/	3.18 (0.93–10.80)	0.07
Prob $> F^a$	0.001		<0.001	

<sup>a</sup> Means overall model *F* statistic.

\* *p* < 0.05.

\*\* *p* < 0.01.

Abbreviations: 95%CI = 95% confidence interval; ASD = autism spectrum disorder; FPL = federal poverty level; N/A = not applicable; Prob = Probability.

current study only included data on weekdays, and previous studies have indicated that recreational screen-viewing activities on weekend days took up more time than on weekdays.<sup>61,62</sup> Thus, future investigations are advised to assess screen time use during the entire week, including weekdays and weekends, to confirm (or refute) our findings. In addition, the caregiver-based questionnaire used to measure 24-HMB in

the current study may be prone to recall bias and inaccuracies. Ideally, these self-reported instruments should be integrated with the gold-standard method of objective device-based tools (e.g., accelerometers) in future studies, which could potentially minimize bias and improve accuracy.

In general, the 24-HMB approach respects the codependence of time spent in PA, SB, and sleep, and meeting these

Table 4  
Associations between meeting 24-hour movement guidelines and difficulty dressing or bathing (adaptive ability).

Difficulty dressing or bathing	Meeting 24-hour movement guidelines as continuous variable		Meeting 24-hour movement guidelines as categorical variable	
	Odds ratio (95%CI)	<i>p</i>	Odds ratio (95%CI)	<i>p</i>
Intercept			0.03 (0.01–0.13)	<0.001
Age, years				
6–13 (reference)	1 (reference)	N/A	1 (reference)	N/A
14–17	0.62 (0.32–1.19)	0.15	0.49 (0.26–0.94)	0.03*
Sex				
Male (reference)	1 (reference)	N/A	1 (reference)	N/A
Female	1.08 (0.54–2.15)	0.83	1.22 (0.63–2.35)	0.56
Overweight				
No (reference)	1 (reference)	N/A	1 (reference)	N/A
Yes	2.33 (1.17–4.65)	0.02*	2.39 (1.20–4.73)	0.01*
Ethnicity				
White (reference)	1 (reference)	N/A	1 (reference)	N/A
Black/African American	0.91 (0.35–2.40)	0.85	0.93 (0.36–2.43)	0.89
American Indian/Alaska native	1 (empty)	N/A	1 (empty)	N/A
Asian	1.24 (0.25–6.22)	0.80	1.22 (0.21–6.99)	0.82
Native Hawaiian and other Pacific Islander	1.10 (0.13–9.07)	0.93	0.95 (0.10–8.87)	0.97
Two or more races	0.70 (0.21–2.29)	0.56	0.85 (0.30–2.46)	0.77
Born $\geq 3$ weeks before due date				
No (reference)	1 (reference)	N/A	1 (reference)	N/A
Yes	0.83 (0.40–1.76)	0.63	0.72 (0.34–1.50)	0.37
ASD severity level				
Mild (reference)	1 (reference)	N/A	1 (reference)	N/A
Moderate and severe	4.82 (2.56–9.07)	<0.001**	4.99 (2.62–9.50)	<0.001**
ASD medication and behavioral treatment				
Neither behavioral treatment nor medication (reference)	1 (reference)	N/A	1 (reference)	N/A
Behavioral treatment and medication	1.74 (0.76–4.02)	0.19	1.75 (0.80–3.84)	0.16
Behavioral treatment only	2.08 (1.00–4.34)	0.05	2.08 (1.02–4.25)	0.04*
Medication only	0.40 (0.09–1.84)	0.24	0.38 (0.07–2.08)	0.27
Household poverty level (Federal Poverty Level)				
0%–99% (reference)	1 (reference)	N/A	1 (reference)	N/A
100%–400%	1.23 (0.52–2.93)	0.64	1.25 (0.54–2.92)	0.60
Highest level of education of primary caregivers				
Less than high school (reference)	1 (reference)	N/A	1 (reference)	N/A
High school	3.19 (0.80–12.72)	0.10	3.25 (0.87–12.17)	0.08
Some college credit or associated degree	1.69 (0.41–6.97)	0.47	1.57 (0.42–5.88)	0.50
College degree or higher	1.56 (0.37–6.57)	0.54	1.28 (0.33–4.90)	0.72
Guidelines met (continuous)	1.10 (0.75–1.62)	0.62	/	/
Guidelines met (categorical)				
None (reference)	/	/	1 (reference)	N/A
Screen time only	/	/	0.49 (0.17–1.43)	0.19
Sleep only	/	/	0.78 (0.36–1.68)	0.52
Physical activity only	/	/	0.11 (0.02–0.66)	0.02*
Screen time + Sleep	/	/	2.01 (0.80–5.01)	0.14
Screen time + Physical activity	/	/	0.36 (0.09–1.46)	0.15
Sleep + Physical activity	/	/	0.52 (0.15–1.84)	0.31
All 3	/	/	1.34 (0.31–5.76)	0.69
Prob > $F^a$	<0.001		<0.001	

<sup>a</sup> Means overall model  $F$  statistic.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

Abbreviations: 95%CI = 95% confidence interval; ASD = Autism spectrum disorder; FPL = Federal poverty level; N/A = Not applicable; Prob = Probability.

guidelines has been observed to be associated with beneficial outcomes (e.g., physical health, academic achievement, and mental health) among neurotypical children and adolescents.<sup>31,63–65</sup> Given that individuals with ASD have more difficulties in complying with 24-HMB guidelines, the

use of 3 discrete items may miss some important information (i.e., sleep quality) and fail to encompass the whole-day movement of this special group. Moreover, findings suggest that some combinations of 24-HMB guidelines, specifically meeting sleep and PA recommendations, were more likely than

Table 5  
Associations between meeting 24-hour movement guidelines and victimization by bullying.

Being bullied	Model 1: Meeting 24-hour movement guidelines as continuous variable		Model 2: Meeting 24-hour movement guidelines as categorical variable	
	Odds ratio (95%CI)	p	Odds ratio (95%CI)	p
Age, years				
6–13 (reference)	1 (reference)	N/A	1 (reference)	N/A
14–17	0.74 (0.47–1.17)	0.20	0.61 (0.38–0.97)	0.04*
Sex				
Male (reference)	1 (reference)	N/A	1 (reference)	N/A
Female	1.20 (0.76–1.89)	0.44	1.23 (0.78–1.95)	0.38
Overweight				
No (reference)	1 (reference)	N/A	1 (reference)	N/A
Yes	0.94 (0.58–1.54)	0.81	0.98 (0.60–1.62)	0.95
Ethnicity				
White (reference)	1 (reference)	N/A	1 (reference)	N/A
Black/African American	0.40 (0.20–0.80)	0.01*	0.42 (0.21–0.84)	0.01*
American Indian/Alaska native	2.81 (0.46–17.13)	0.26	2.28 (0.32–16.24)	0.41
Asian	0.95 (0.44–2.05)	0.90	0.95 (0.43–2.08)	0.90
Native Hawaiian and other Pacific Islander	0.78 (0.39–1.52)	0.46	0.78 (0.39–1.59)	0.50
Two or more races	0.80 (0.28–2.28)	0.67	0.76 (0.29–2.00)	0.58
Born $\geq 3$ weeks before due date				
No (reference)	1 (reference)	N/A	1 (reference)	N/A
Yes	0.96 (0.59–1.58)	0.87	1.00 (0.61–1.63)	1.00
ASD severity level				
Mild (reference)	1 (reference)	N/A	1 (reference)	N/A
Moderate and severe	1.69 (1.14–2.52)	0.01*	1.78 (1.19–2.66)	0.01*
ASD medication and behavioral treatment				
Neither behavioral treatment nor medication (reference)	1 (reference)	N/A	1 (reference)	N/A
Behavioral treatment and medication	2.11 (1.18–3.77)	0.01*	2.11 (1.21–3.70)	0.01*
Behavioral treatment only	1.27 (0.77–2.08)	0.35	1.27 (0.77–2.10)	0.35
Medication only	2.21 (0.88–5.56)	0.09	2.16 (0.85–5.47)	0.11
Household poverty level (Federal Poverty Level)				
0%–99% (reference)	1 (reference)	N/A	1 (reference)	N/A
100%–400%	0.86 (0.39–1.89)	0.71	0.87 (0.39–1.95)	0.73
Highest level of education of primary caregivers				
Less than high school (reference)	1 (reference)	N/A	1 (reference)	N/A
High school	2.30 (0.82–6.46)	0.11	2.63 (0.95–7.27)	0.06
Some college credit or associated degree	5.62 (1.85–17.02)	0.002**	6.35 (2.08–19.34)	0.001**
College degree or higher	3.95 (1.36–11.48)	0.01*	4.35 (1.46–12.99)	0.01*
Guidelines met (continuous)	0.78 (0.59–1.02)	0.07	/	/
Guidelines met (categorical)				
None (reference)	/	/	1 (reference)	N/A
Screen time only	/	/	0.50 (0.21–1.16)	0.11
Sleep only	/	/	1.22 (0.72–2.06)	0.46
Physical activity only	/	/	1.12 (0.46–2.71)	0.80
Screen time + Sleep	/	/	0.80 (0.37–1.73)	0.58
Screen time + Physical activity	/	/	0.44 (0.04–4.63)	0.49
Sleep + Physical activity	/	/	0.66 (0.27–1.61)	0.37
All 3	/	/	0.38 (0.15–0.99)	0.05
Prob > $F^a$	<0.001		<0.001	

<sup>a</sup> Means overall model  $F$  statistic.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

Abbreviations: 95%CI = 95% confidence interval; ASD = autism spectrum disorder; FPL = federal poverty level; N/A = Not applicable; Prob = Probability.

others to be associated with beneficial results concerning QoL-related indicators in children and adolescents with ASD. Thus, an adapted and more nuanced 24-HMB framework may be needed for this special cohort. To address the limitations of the current study and to develop a more nuanced 24-HMB framework for special cohorts (e.g., children with ASD), further research using more robust measures is needed.

## 5. Conclusion

Our findings suggest that children and adolescents with ASD often fail to adhere to the 24-HMB guidelines (sleep, PA, and SB). This phenomenon may contribute to a wide range of problems children and adolescents with ASD have to face, given that the compliance with these 24-HMB guidelines has a



Table 6  
Associations between meeting 24-hour movement guidelines and behavioral problems.

Behavioral problems (severity level)	Meeting 24-hour movement guidelines as continuous variable		Meeting 24-hour movement guidelines as categorical variable	
	Odds ratio (95%CI)	p	Odds ratio (95%CI)	p
Age, years				
6–13 (reference)	1 (reference)	N/A	1 (reference)	N/A
14–17	1.07 (0.98–1.16)	0.16	2.60 (1.28–5.30)	0.01*
Sex				
Male (reference)	1 (reference)	N/A	1 (reference)	N/A
Female	1.03 (0.42–2.53)	0.94	1.06 (0.43–2.64)	0.90
Overweight				
No (reference)	1 (reference)	N/A	1 (reference)	N/A
Yes	1.21 (0.55–2.64)	0.64	1.09 (0.47–2.53)	0.84
Ethnicity				
White (reference)	1 (reference)	N/A	1 (reference)	N/A
Black/African American	0.73 (0.31–1.74)	0.48	0.86 (0.38–1.96)	0.73
American Indian/Alaska native	7.34 (2.70–19.94)	<0.001**	11.90 (3.02–46.92)	<0.001**
Asian	1.45 (0.58–3.62)	0.43	1.36 (0.50–3.70)	0.55
Native Hawaiian and other Pacific Islander	1 (empty)	N/A	1 (empty)	N/A
Two or more races	0.63 (0.26–1.48)	0.29	0.80 (0.29–2.17)	0.66
Born $\geq 3$ weeks before due date				
No (reference)	1 (reference)	N/A	1 (reference)	N/A
Yes	1.13 (0.53–2.41)	0.76	1.07 (0.47–2.45)	0.88
ASD severity level				
Mild (reference)	1 (reference)	N/A	1 (reference)	N/A
Moderate and severe	6.51 (3.34–12.72)	<0.001**	6.72 (3.38–13.36)	<0.001**
ASD medication and behavioral treatment				
Neither behavioral treatment nor medication (reference)	1 (reference)	N/A	1 (reference)	N/A
Behavioral treatment and medication	1.55 (0.63–3.77)	0.34	1.55 (0.64–3.75)	0.33
Behavioral treatment only	0.52 (0.25–1.06)	0.07	0.48 (0.23–1.01)	0.05
Medication only	1.00 (0.35–2.86)	1.00	1.12 (0.37–3.39)	0.84
Household poverty level (Federal Poverty Level)				
0%–99% (reference)	1 (reference)	N/A	1 (reference)	N/A
100%–400%	0.75 (0.35–1.63)	0.47	0.77 (0.38–1.53)	0.45
Highest level of education of primary caregivers				
Less than high school (reference)	1 (reference)	N/A	1 (reference)	N/A
High school	1.42 (0.48–4.19)	0.53	1.12 (0.36–3.49)	0.84
Some college credit or associated degree	1.69 (0.64–4.46)	0.29	1.42 (0.52–3.83)	0.49
College degree or higher	1.33 (0.49–3.59)	0.57	1.15 (0.40–3.25)	0.80
Guidelines met (continuous)	0.89 (0.60–1.31)	0.54	/	/
Guidelines met (categorical)				
None (reference)	/	/	1 (reference)	N/A
Screen time only	/	/	0.57 (0.24–1.37)	0.21
Sleep only	/	/	0.41 (0.17–1.02)	0.06
Physical activity only	/	/	0.67 (0.24–1.93)	0.46
Screen time + Sleep	/	/	0.71 (0.25–2.03)	0.52
Screen time + Physical activity	/	/	0.52 (0.13–2.00)	0.34
Sleep + Physical activity	/	/	0.17 (0.04–0.71)	0.01*
All 3	/	/	1.11 (0.29–4.23)	0.88
Prob > $F^a$	<0.001		<0.001	

<sup>a</sup> Means overall model  $F$  statistic.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

Abbreviation: 95%CI = 95% confidence interval; ASD = Autism spectrum disorder; FPL = Federal poverty level; N/A = not applicable; Prob = Probability.

predictive value for QoL indicators. Researchers are encouraged to investigate factors that prevent this group from adhering to 24-HMB guidelines as well as the effectiveness of compliance with 24-HMB guidelines in different real-life domains. Parents and educators should assist this group of individuals in their quest for a healthier lifestyle.

### 5.1. Availability of data and materials

According to the 2020 NSCH methodology report,<sup>66</sup> participation in the 2020 NSCH was voluntary, and all data collected that could potentially identify an individual person are confidential. Data are kept private in accordance with applicable

law. Respondents are assured of the confidentiality of their replies in accordance with 13 U.S.C. Section 9. All access to Title 13 data from this survey is restricted to Census Bureau employees and those holding Census Bureau Special Sworn Status pursuant to 13 U.S.C. Section 23(c). The Screener and Topical public use data files went through a thorough disclosure review process and were approved by the Census Disclosure Review Board prior to release.<sup>66</sup>

The datasets generated and/or analyzed during the current study are available in the U.S. Census Bureau repository, <https://www.census.gov/programs-surveys/nsch/data/datasets.html>.

### Competing interests

The authors declare that they have no competing interests.

### Authors' contributions

CK analyzed the data and wrote the manuscript drafts. All the co-authors read and critically revised manuscript drafts. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

### Acknowledgments

Supported by Start-up Research Grant of Shenzhen University (20200807163056003) and Start-Up Research Grant (PeacockPlan: 20191105534C). We thank all the co-authors and other team members who contributed to this research.

### Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:[10.1016/j.jshs.2022.08.003](https://doi.org/10.1016/j.jshs.2022.08.003).

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