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Movement behaviors and mental health of caregivers of preschoolers in China during the COVID-19 pandemic

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ABSTRACT

This study aimed to examine the associations between physical activity (PA), sedentary behavior (SB), sleep, and the mental health of caregivers of preschool children following the COVID-19 outbreak. From 5 October to 16 December 2020, responses from 2476 respondents in China were collated through an online survey or a written questionnaire. Movement behaviors (PA, SB, screen time, and sleep), mental health (depression, anxiety, and stress), and demographic information were self-reported by the respondents. Linear mixed models were used for data analysis. Valid responses were received from 2002 caregivers (35.5 ± 4.9 years old, 76.3% females) of children between 3 and 6 years old in China (Hong Kong 3.2%, Shanghai 20.6%, Guangzhou 34.1%, Guiyang 26.7%, Xuzhou 11.3%, Xi'an 4.1%). A higher level of PA was associated with a lower score of depression, while lower SB and longer sleep duration were associated with lower scores of depression, anxiety, and stress. Meeting the Canadian 24-h movement guidelines was associated with less symptoms of depression, anxiety, and stress. Higher PA was associated with lower levels of depression, while longer sleep and lower SB were associated with better scores of depression, anxiety, and stress. Meeting the Canadian 24-h movement guidelines has been associated with better mental health during the COVID-19 pandemic. Interventions to improve mental health among caregivers should involve enhancing their overall movement behaviors.

1. Introduction

The mental health of the general public, clinic workers, and patients has declined following the coronavirus disease 2019 (COVID-19) outbreak (Vindegaard and Benros, 2020). A study conducted in China established that more than half of respondents, aged 12–59 years, experienced moderate or severe psychological impact due to the pandemic, and 16.5%, 28.8%, and 8.1% experienced moderate to severe depression, anxiety, and stress, respectively (Wang et al., 2020). However, the challenges for families with children, were higher. Some caregivers lost their jobs and the income reduction led to economic pressure (Gassman-Pines et al., 2020). Furthermore, increased education and caregiving responsibilities due to school closures and new routines, also lead to higher pressure (Carroll et al., 2020). Studies found that as compared to adults who did not have children, those living with children aged under 18, had higher chances of experiencing moderate to severe anxiety (The Centre for Addiction and Mental Health, 2020), and

higher stress levels during the pandemic (American Psychological Association, 2020). A study reported that a large number of caregivers of 3–14-year-olds in Japan experienced moderate or severe mental stress during the pandemic, which was more than double the numbers reported in the 2016 national survey (Horiuchi et al., 2020). Furthermore, parents having younger children are more likely to experience parenting-related exhaustion (e.g., burnout) during the pandemic, as compared to parents with older children (Marchetti et al., 2020). Of further note, the negative impact of stressful events on mental health may last for a long period of time. For example, over one in five hospital employees still experienced moderate to high levels of depression three years after the breakout of severe acute respiratory syndrome (Liu et al., 2012).

Preschool children spend a large proportion of their time with their caregivers (e.g., father, mother), and therefore the caregiver's mental health has a strong influence on them. More specifically, parents' mental health problems (e.g., depression, anxiety, stress) were found to be

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positively associated with preschoolers' behavioral and emotional problems (Fitzsimons et al., 2017), while negatively associated with the amount of active play (Walton et al., 2014) and sleep quality (Tyler et al., 2019). Chemtob et al. found that preschool-aged children of mothers with higher levels of mental health problems suffered more psychological and physical abuse (Chemtob et al., 2013). Furthermore, a recent systematic review and meta-analysis summarized 41 studies about parental mental health and physical health of children under 18 years old, and reported that children, whose parents had mental disorders, were less healthy (e.g., higher risk of injury, malnutrition, asthma) (Pierce et al., 2020). Therefore, the mental health needs of caregivers of preschoolers are unique, and the influencing factors should be identified.

A healthy and active lifestyle is considered beneficial for an adult's mental health. Physical activity (PA) and sleep have a protective effect on mental health (Guallar-Castillón et al., 2014; Zhai et al., 2015), while extended sedentary behavior (SB) generally has a negative impact (Guallar-Castillón et al., 2014). This has also been observed during the COVID-19 pandemic as reduced PA and sleep were associated with increased symptoms of depression, anxiety, and stress (Stanton et al., 2020). Alongside the individual benefits, the combined effect of movement behaviors in a 24-h day on health has attracted attention recently (Rollo et al., 2020). The Canadian 24-h movement guidelines for adults recommend the specific duration of PA, SB, and sleep to ensure optimal health (Ross et al., 2020). However, precautionary measures during the COVID-19 pandemic, such as social distancing and working from home have led to a less healthy lifestyle among caregivers. A study in Canada stated that most parents of children between 18 months and 5 years reported a decrease in PA and increase in the screen time following the COVID-19 outbreak (Carroll et al., 2020). Another study among Australian caregivers of school-aged children found that caregivers engaged in less light-intensity PA than they did before the pandemic (Curtis et al., 2021). The relationships between movement behaviors and mental health of caregivers during the COVID-19 pandemic, however, have not been examined. This study aimed to assess the following in caregivers of preschoolers during the COVID-19 pandemic in China: (1) the associations between PA, SB, sleep, and mental health; (2) the relationship between meeting the Canadian 24-h guidelines and mental health. The hypotheses are as follows: (1) higher PA, lower SB, and higher sleep are associated with lower symptoms of depression, anxiety, and stress; (2) meeting the Canadian 24-h movement guidelines would be associated with lower symptoms of depression, anxiety, and stress.

2. Methods

2.1. Participants

This cross-sectional study was conducted in six cities (Hong Kong, Shanghai, Guangzhou, Guiyang, Xuzhou, and Xi'an) in China, using snowball sampling. These six cities are located in the east, south, southwest, and northwest of China (see Supplementary Fig. 1). More specifically, the online questionnaire was developed through the Wenjuanxing platform (<https://www.wjx.cn/>). The link was distributed through different social networks, e.g., WeChat and WhatsApp via research collaborators in each city. In addition to the online questionnaire, hard-copy versions were provided if requested and were only used in Hong Kong.

The specific inclusion criteria of the respondents included the following: (1) being the parent or the primary caregiver of at least one child aged between 3 and 6; and (2) the child is healthy and does not have any physical or mental illness. A total of 2476 caregivers responded to the survey through the Wenjuanxing platform or a hardcopy, from 5 October to 16 December 2020 (following the peak of the COVID-19 outbreak). During the time period, a small number of new confirmed cases were reported in Hong Kong and Shanghai, while there were no new infection cases in the other four cities. Based on a power of 0.80, a p

value of 0.05 and 10 predictors in a regression model, the sample size can detect an effect size f^2 of less than 0.01. A consent form was signed by each respondent. This study has been registered on the Open Science Framework (OSF; DOI: [10.17605/OSF.IO/JFTGP](https://doi.org/10.17605/OSF.IO/JFTGP)), and the ethics approval has been obtained from the Research Ethics Committee, Hong Kong Baptist University (Ref. No.: 19200526).

2.2. Measures

2.2.1. Physical activity and sedentary behavior

The International Physical Activity Questionnaire-Short Form (IPAQ) was used to measure the PA and SB of caregivers over last seven days (IPAQ Research Committee, 2005). This included walking, moderate-intensity PA (MPA), vigorous-intensity PA (VPA), and sitting time. The total PA (MET-hour/day) was defined as the sum of all three categories.

Data screening of PA followed the standardized screening criteria for IPAQ (IPAQ Research Committee, 2005), SB was considered invalid and excluded from the final analysis if it was longer than 12 h (Marshall et al., 2002; Harrington et al., 2014).

2.2.2. Screen time

Screen time was measured through a self-reported question: Over the last seven days, how much time on average have you spent on sedentary screen time (watching TV, using computers/tablets/smartphones, etc.)? The response was considered invalid if it was longer than 12 h (Marshall et al., 2002; Harrington et al., 2014).

2.2.3. Sleep

Sleep was measured through a self-reported question: Over the last seven days, how much time on average have you slept for? Data were excluded if it was less than 1 h or more than 20 h (Malheiros et al., 2021).

2.2.4. Compliance with the Canadian 24-h movement guidelines

The definition of meeting the 24-h movement guidelines is as follows: (1) PA guideline: at least 150 min of moderate-to-vigorous intensity PA (MVPA) per week; (2) SB guideline: a maximum of 8 h of SB and a maximum of 3 h of screen time per day; and (3) sleep guideline: having 7 to 9 h of sleep duration per day (Ross et al., 2020).

2.2.5. Mental health

The mental health of caregivers was assessed using the Chinese Version of the Depression Anxiety Stress Scale - 21 (DASS21) (Gong et al., 2010; Moussa et al., 2001), which has been validated for adults in Hong Kong and mainland China. DASS constitutes 21 items, with seven items in each of the three subscales (depression, anxiety, and stress). Four options were provided for each item, from "0, did not apply to me at all" to "3, applied to me very much or most of the time." Caregivers were asked to rate their feelings over the last seven days.

The scores of the three subscales were calculated as the sum of the relevant items and multiplied by two. Additionally, depression was classified as normal (0–9) and having symptoms (more than 9); anxiety was classified as normal (0–7) and having symptoms (more than 8); and stress was classified as normal (0–14) and having symptoms (more than 15) (Lee, 2019). Having symptoms include "mild," "moderate," "severe," and "extremely severe."

2.2.6. Demographic information

Information regarding caregivers' age, sex, body weight, height, education level, family income, city, and if they were asked to work from home during the COVID-19 pandemic, was collated through a self-reported questionnaire. Based on body mass index (BMI) calculated as weight (kg)/height (m²), caregivers were classified as non-overweight (BMI < 23.0) and overweight or obese (BMI ≥ 23.0) according to the World Health Organization (WHO) cut-off point for Asian adults (WHO

expert consultation, 2004). Education level was categorized as below degree and degree or higher. For families based in Hong Kong, according to the family income median reported by Census and Statistics Department, Hong Kong Special Administrative Region (Census and Statistics Department HKSAR, 2020), the family income per month for three groups were as follows: low (< 25,000 HKD), medium (25,000–34,999 HKD), and high (≥ 35,000 HKD). For families in mainland China, the criteria were as follows: low (< 4999 Yuan), medium (5000–9999 Yuan), and high (≥ 10,000 Yuan), based on the family income median reported by National Bureau of Statistics of China (National Bureau of Statistics of China, 2021).

2.3. Statistical analyses

Variables were checked for normality analysis. Mean and standard deviation were used to present continuous variables. The number of participants and percentage were presented for categorial variables. The differences in demographic characteristics, movement behaviors, and mental health across cities were analyzed using one-way analysis of variance or Chi-Square tests.

Linear mixed models were used to examine the associations between

individual variables and mental health scores (depression, anxiety, and stress). Location (i.e., city) and age of children were adjusted and treated as fixed factors. After adjusting all demographic factors, linear mixed models were used to examine the associations between movement behaviors and mental health scores. Linear mixed models were also used to determine the association between meeting (vs. not meeting) the Canadian 24-h movement guidelines and mental health scores, which were adjusted for all demographic factors. SPSS 27 software (IBM, Armonk, New York) was used to conduct statistical analyses. The two-sided significance level was set at $p < 0.05$.

3. Results

A total of 2476 responses were received and 2261 responses (91.3%) remained after the initial screening, with 215 caregivers excluded for the following reasons: declined to sign the consent form ($n = 18$), submitted blank questionnaires ($n = 5$), the child was not in the target age range ($n = 87$), and did not reside in either of the 6 cities during the pandemic ($n = 105$). After further data cleaning, 2002 caregivers (35.5 ± 4.9 years old, 76.3% females) provided complete and valid data of demographic information, movement behaviors, and mental health and

Table 1
Participants' characteristics and compliance with the 24-h movement guidelines.

	Hong Kong (n = 64)	Shanghai (n = 412)	Guangzhou (n = 683)	Guiyang (n = 534)	Xuzhou (n = 226)	Xi'an (n = 83)	Total (n = 2002)	P value
Age of children (years) mean ± SD	4.2 ± 0.8	4.8 ± 0.9	4.7 ± 0.9	4.5 ± 0.9	4.4 ± 0.8	4.4 ± 0.8	4.6 ± 0.9	<0.001
Age of caregivers (years) mean ± SD	37.5 ± 4.6	35.0 ± 4.0	37.6 ± 4.8	34.1 ± 4.8	34.3 ± 4.8	32.6 ± 3.8	35.5 ± 4.9	<0.001
Sex n (%)								
Male	10 (15.6%)	80 (19.4%)	172 (25.2%)	142 (26.6%)	49 (21.7%)	22 (26.5%)	475 (23.7%)	0.059
Female	54 (84.4%)	332 (80.6%)	511 (74.8%)	392 (73.4%)	177 (78.3%)	61 (73.5%)	1527 (76.3%)	
Weight status n (%)								
Non-overweight	43 (67.2%)	258 (62.6%)	433 (63.4%)	342 (64.0%)	131 (58.0%)	47 (56.6%)	1254 (62.6%)	0.470
Overweight or obese	21 (32.8%)	154 (37.4%)	250 (36.6%)	192 (36.0%)	95 (42.0%)	36 (43.4%)	748 (37.4%)	
Education level n (%)								
Below degree	39 (60.9%)	89 (21.6%)	138 (20.2%)	249 (46.6%)	80 (35.4%)	67 (80.7%)	662 (33.1%)	<0.001
Degree or higher	25 (39.1%)	323 (78.4%)	545 (79.8%)	285 (53.4%)	146 (64.6%)	16 (19.3%)	1340 (66.9%)	
Family income n (%)								
Low income	23 (35.9%)	9 (2.2%)	20 (2.9%)	105 (19.7%)	18 (8.0%)	33 (39.8%)	208 (10.4%)	<0.001
Medium income	23 (35.9%)	57 (13.8%)	111 (16.3%)	174 (32.6%)	73 (32.3%)	28 (33.7%)	466 (23.3%)	
High income	18 (28.1%)	346 (84.0%)	552 (80.8%)	255 (47.8%)	135 (59.7%)	22 (26.5%)	1328 (66.3%)	
Work from home during the COVID-19 n (%)								
Yes	20 (31.3%)	198 (48.1%)	336 (49.2%)	215 (40.3%)	113 (50.0%)	29 (34.9%)	911 (45.5%)	0.001
No	44 (68.8%)	214 (51.9%)	347 (50.8%)	319 (59.7%)	113 (50.0%)	54 (65.1%)	1091 (54.5%)	
Compliance with guidelines n (%)								
PA	27 (42.2%)	167 (40.5%)	344 (50.4%)	180 (33.7%)	87 (38.5%)	31 (37.3%)	836 (41.8%)	<0.001
SB	39 (60.9%)	151 (36.7%)	357 (52.3%)	284 (53.2%)	105 (46.5%)	48 (57.8%)	984 (49.2%)	<0.001
Sleep	37 (57.8%)	318 (77.2%)	465 (68.1%)	396 (74.2%)	181 (80.1%)	59 (71.1%)	1456 (72.7%)	<0.001
PA + SB	15 (23.4%)	75 (18.2%)	202 (29.6%)	107 (20.0%)	47 (20.8%)	16 (19.3%)	462 (23.1%)	<0.001
PA + sleep	19 (29.7%)	131 (31.8%)	218 (31.9%)	129 (24.2%)	66 (29.2%)	25 (30.1%)	588 (29.4%)	0.066
SB + sleep	24 (37.5%)	103 (25.0%)	220 (32.2%)	199 (37.3%)	83 (36.7%)	32 (38.6%)	661 (33.0%)	0.001
Number of guidelines met								
All three	11 (17.2%)	54 (13.1%)	113 (16.5%)	74 (13.9%)	37 (16.4%)	13 (15.7%)	302 (15.1%)	0.103
None	8 (12.5%)	31 (7.5%)	44 (6.4%)	35 (6.6%)	12 (5.3%)	5 (6.0%)	135 (6.7%)	
One	20 (31.3%)	180 (43.7%)	225 (32.9%)	212 (39.7%)	92 (40.7%)	31 (37.3%)	760 (38.0%)	
Two	25 (39.1%)	147 (35.7%)	301 (44.1%)	213 (39.9%)	85 (37.6%)	34 (41.0%)	805 (40.2%)	
Mental health n (%)								
Depression								
Normal	52 (81.3%)	357 (86.7%)	601 (88.0%)	460 (86.1%)	202 (89.4%)	71 (85.5%)	1743 (87.1%)	0.527
Having symptoms	12 (18.8%)	55 (13.3%)	82 (12.0%)	74 (13.9%)	24 (10.6%)	12 (14.5%)	259 (12.9%)	
Anxiety								
Normal	49 (76.6%)	352 (85.4%)	584 (85.5%)	448 (83.9%)	199 (88.1%)	60 (72.3%)	1692 (84.5%)	0.008
Having symptoms	15 (23.4%)	60 (14.6%)	99 (14.5%)	86 (16.1%)	27 (11.9%)	23 (27.7%)	310 (15.5%)	
Stress								
Normal	55 (85.9%)	378 (91.7%)	635 (93.0%)	489 (91.6%)	206 (91.2%)	72 (86.7%)	1835 (91.7%)	0.222
Having symptoms	9 (14.1%)	34 (8.3%)	48 (7.0%)	45 (8.4%)	20 (8.8%)	11 (13.3%)	167 (8.3%)	

Abbreviations: PA, physical activity; SB, sedentary behavior.

were included in the final data analysis. Of them, 99.6% were parents (i.e., fathers and mothers) and the remaining were primary caregivers.

The characteristic information of the participants is presented in Table 1. Overall, 37.4% of caregivers were overweight or obese, 66.9% had an educational degree or higher, and 45.5% were asked to work from home during the COVID-19 pandemic. Two thirds of the respondents were from high income families. Compliance with the Canadian 24-h movement guidelines varied from 13.1% to 17.2% across cities. On average, 6.7% of the caregivers met none of the guidelines.

Depression, anxiety, and stress, and their differences across the cities are shown in Table 1. Separately, 12.9%, 15.5%, and 8.3% of the caregivers had symptoms of depression, anxiety, and stress.

The associations between individual movement behaviors and mental health are presented in Table 2. After adjusting for covariates (children's age, caregiver's age, sex, weight status, education level, family income, and if they were working from home during the pandemic), participation in more PA of all intensities was associated with a lower level of depression ($B = -0.06$; 95% CI = $-0.11, -0.01$). A higher level of SB was associated with higher levels of depression ($B = 0.11$; 95% CI = $0.03, 0.20$), anxiety ($B = 0.10$; 95% CI = $0.03, 0.18$), and stress ($B = 0.20$; 95% CI = $0.10, 0.30$). A longer sleep duration was associated with lower levels of depression ($B = -0.24$; 95% CI = $-0.37, -0.11$), anxiety ($B = -0.23$; 95% CI = $-0.34, -0.12$), and stress ($B = -0.33$; 95% CI = $-0.48, -0.17$).

The associations between meeting the Canadian 24-h guidelines (individual and in combination) and mental health are presented in Table 3. Meeting the PA guideline was associated with a lower level of depression ($B = -0.62$; 95% CI = $-1.07, -0.17$), while meeting the SB guideline was associated with lower levels of depression ($B = -0.73$; 95% CI = $-1.19, -0.28$), anxiety ($B = -0.62$; 95% CI = $-1.00, -0.24$), and stress ($B = -1.24$; 95% CI = $-1.79, -0.69$). Meeting the sleep guideline was only associated with a lower level of stress ($B = -0.69$;

95% CI = $-1.29, -0.08$).

Meeting PA + SB guidelines or SB + sleep guidelines was associated with less symptoms of depression, anxiety, and stress. Meeting all guidelines was associated with lower levels of depression ($B = -0.71$; 95% CI = $-1.33, -0.09$) and stress ($B = -0.97$; 95% CI = $-1.72, -0.22$). The dose-response relationships between the number of guidelines met and depression ($B = -0.60$; 95% CI = $-0.87, -0.33$), anxiety ($B = -0.39$; 95% CI = $-0.62, -0.16$), and stress ($B = -0.88$; 95% CI = $-1.21, -0.55$) were identified. Caregivers who met more guidelines had less symptoms of depression, anxiety, and stress.

4. Discussion

This study assessed the movement behaviors (PA, SB, and sleep) and explored their relationship with the mental health of caregivers of preschoolers in China during the COVID-19 pandemic. Results suggest that engaging in less total PA, more SB, and a shorter sleep duration, are associated with higher levels of depression. Furthermore, individuals having more SB and shorter sleep duration had higher levels of anxiety and stress. Caregivers who met more Canadian 24-h guidelines had better mental health than those who did not meet any of the guidelines.

While comparing this study with previous studies, the time frame of data collection must be considered. This study was conducted after the peak of the COVID-19 outbreak in China when some precautionary measures were still being implemented, such as border entry restrictions, compulsory quarantine and isolation, social distancing, and school closures (in Hong Kong). The compliance in this study was higher than that found in another study conducted among young adults (18 to 35 years) in Hong Kong, which observed that 29.6%, 42.5%, and 41.4% of the participants met the PA, SB, and sleep guidelines, respectively (Zheng et al., 2020). The discrepancy could be due to several reasons including differences in the mean age (35.5 years vs. 21.1 years), the

Table 2
Associations between caregivers' movement behaviors and mental health.

	Depression		Anxiety		Stress	
	Crude model ^a	Multivariate model ^b	Crude model ^a	Multivariate model ^b	Crude model ^a	Multivariate model ^b
	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)	B (95% CI)
Age	0.02 (-0.03, 0.07)	0.00 (-0.05, 0.05)	-0.00 (-0.04, 0.04)	-0.01 (-0.05, 0.03)	0.04 (-0.02, 0.10)	0.01 (-0.05, 0.07)
Sex (reference: Female)						
Male	0.76 (0.24, 1.28)**	0.50 (-0.07, 1.07)	0.09 (-0.36, 0.52)	-0.16 (-0.65, 0.32)	0.96 (0.33, 1.59)**	0.49 (-0.20, 1.17)
Weight status (reference: Non-overweight)						
Overweight	0.73 (0.27, 1.19)**	0.57 (0.07, 1.07)*	0.39 (-0.00, 0.77)	0.45 (0.03, 0.88)*	1.06 (0.51, 1.61)**	0.89 (0.29, 1.49)**
Education level (reference: Lower than degree)						
Degree or higher	-0.08 (-0.58, 0.42)	-0.15 (-0.67, 0.38)	0.16 (-0.26, 0.58)	0.11 (-0.34, 0.55)	0.16 (-0.45, 0.76)	-0.14 (-0.76, 0.49)
Family income (reference: Low income)						
Medium income	-0.41 (-1.25, 0.44)	-0.50 (-1.35, 0.35)	-0.08 (-0.79, 0.64)	-0.17 (-0.88, 0.55)	-0.57 (-1.59, 0.45)	-0.77 (-1.79, 0.24)
High income	-0.75 (-1.56, 0.05)	-0.87 (-1.69, -0.04)*	-0.22 (-0.89, 0.46)	-0.35 (-1.05, 0.34)	-0.21 (-1.18, 0.76)	-0.47 (-1.47, 0.52)
Work from home during the COVID-19 pandemic (reference: No)						
Yes	-0.13 (-0.58, 0.32)	-0.21 (-0.65, 0.24)	-0.09 (-0.46, 0.29)	-0.17 (-0.55, 0.21)	0.08 (-0.46, 0.62)	-0.02 (-0.56, 0.52)
Walking MET-h/day	-0.11 (-0.20, -0.01)*		-0.03 (-0.11, 0.05)		-0.05 (-0.17, 0.06)	
MVPA MET-h/day	-0.09 (-0.15, -0.02)**		-0.05 (-0.10, 0.01)		-0.07 (-0.15, 0.01)	
Total PA MET-h/day	-0.08 (-0.12, -0.03)**	-0.06 (-0.11, -0.01)*	-0.03 (-0.07, 0.01)	-0.02 (-0.06, 0.03)	-0.05 (-0.11, 0.01)	-0.03 (-0.09, 0.03)
Sedentary behavior h/day	0.11 (0.03, 0.19)**	0.11 (0.03, 0.20)*	0.11 (0.04, 0.18)**	0.10 (0.03, 0.18)**	0.21 (0.11, 0.30)**	0.20 (0.10, 0.30)**
Screen time h/day	0.16 (0.09, 0.23)**		0.15 (0.09, 0.21)**		0.25 (0.16, 0.33)**	
Sleep h/day	-0.28 (-0.41, -0.15)**	-0.24 (-0.37, -0.11)**	-0.24 (-0.35, -0.13)**	-0.23 (-0.34, -0.12)**	-0.37 (-0.52, -0.21)**	-0.33 (-0.48, -0.17)**

Abbreviations: 95% CI, 95% confidence interval; PA, physical activity; MVPA, moderate-to-vigorous intensity physical activity.

** $p < 0.01$, * $p < 0.05$.

^a Crude model: Bivariable association between individual correlate variables and outcome variable adjusting for city and age of children.

^b Multivariate model: Adjusted for city, age of children, and all other variables in the multivariate model.

Table 3
Associations between meeting 24-h movement guidelines and mental health.

Meet guidelines	Depression	Anxiety	Stress
	B (95% CI)	B (95% CI)	B (95% CI)
Meeting (vs. not meeting) individual guideline			
At least PA	-0.62 (-1.07, -0.17)**	-0.17 (-0.55, 0.22)	-0.49 (-1.04, 0.05)
At least sedentary behavior	-0.73 (-1.19, -0.28)**	-0.62 (-1.00, -0.24)**	-1.24 (-1.79, -0.69)**
At least sleep	-0.31 (-0.81, 0.19)	-0.32 (-0.74, 0.11)	-0.69 (-1.29, -0.08)*
Meeting (vs. not meeting) specific combinations			
At least PA + sedentary behavior	-0.89 (-1.42, -0.36)**	-0.48 (-0.93, -0.03)*	-1.22 (-1.86, -0.58)**
At least PA + sleep	-0.48 (-0.97, 0.01)	-0.11 (-0.53, 0.30)	-0.50 (-1.09, 0.09)
At least sedentary behavior + sleep	-0.54 (-1.02, -0.07)*	-0.52 (-0.92, -0.12)*	-1.08 (-1.65, -0.50)**
All three	-0.71 (-1.33, -0.09)*	-0.30 (-0.82, 0.23)	-0.97 (-1.72, -0.22)*
Number of guidelines met			
Meet none	Reference	Reference	Reference
Meet one	-1.25 (-2.17, -0.32)**	-0.76 (-1.54, 0.02)	-1.30 (-2.41, -0.19)*
Meet two	-1.75 (-2.67, -0.83)**	-1.24 (-2.02, -0.47)**	-2.24 (-3.35, -1.13)**
Meet three	-2.10 (-3.13, -1.08)**	-1.24 (-2.10, -0.37)**	-2.63 (-3.86, -1.40)**
Trend analysis	-0.60 (-0.87, -0.33)**	-0.39 (-0.62, -0.16)**	-0.88 (-1.21, -0.55)**

Notes. All models were adjusted for age of children, caregiver's age, sex, weight status, education level, family income, whether work from home during the pandemic, and city.

Abbreviations: 95% CI, 95% confidence interval; PA, physical activity.

** p < 0.01, * p < 0.05.

time of data collection (October to December 2020 vs. April 2020), and the guidelines. Studies regarding the Canadian 24-h movement guidelines are limited as these were established fairly recently (October 2020), therefore a comparison is difficult. Additionally, it should be noted that the screen time measured in this study is not limited to leisure time and therefore the compliance with the SB guideline may be underestimated.

Exposure to a pandemic may have immediate and prolonged negative impact on mental health in all populations. It was observed that one out of ten caregivers had symptoms of moderate to severe depression, anxiety, and stress, which was less than what was reported in a previous study (≥ 30%) conducted among adults in China in early 2020 (Wang et al., 2020). This variation could be due to the different stages of the pandemic and the seriousness. A previous study showed that psychological distress decreases as the time went by and the seriousness of the pandemic decreased, due to the effective virus control and prevention measures in China (Qiu et al., 2020). The present study was conducted at a point where the pandemic was mostly under control, and most of the respondents (96.8%) had resumed going to their workplace and kindergartens had reopened even though the epidemic was still recurring on a small scale. This finding supports that the impact of a stressful event may last for an extended period of time. Follow-up and longitudinal studies are warranted to investigate the long-term impacts of the COVID-19 pandemic on mental health. Furthermore, in view of its multi-dimensional influence on their child's development, parents' mental health deserves more attention and strategies need to be adopted to improve the wellbeing of the whole family.

A negative association was found between total PA and depression after adjusting for demographic information and other behaviors, and meeting the PA guideline was associated with depression. These findings are consistent with a recent systematic review, which found that PA was associated with lower depressive symptoms and lower odds ratio of

having depression (Dishman et al., 2021). However, PA-related indicators or meeting the PA guideline were not correlated with anxiety and stress, and these findings do not support the hypotheses. A study conducted with Australian adults observed that individuals whose PA decreased after the onset of COVID-19 pandemic had higher depression, anxiety, and stress related issues (Stanton et al., 2020). However, a longitudinal study of adults found that regular PA could reduce the possibility of suffering from depression in future, but not anxiety (Harvey et al., 2017). The lack of associations between PA and anxiety and stress indicates that increased participation in PA is not merely correlated to a general improvement of mental health and is less likely to affect the shared promoters of depression and anxiety. The positive association between SB and mental health was reported in both univariable and multivariable models. To predict mental health, multivariable models including screen time, instead of SB, were also conducted (data not shown), and positive associations were found between screen time and all three forms of mental health. Also, the findings regarding the associations between meeting the SB guideline and mental health, were consistent. These findings are consistent with the hypotheses proposed in this study and previous studies. A previous study found that adults whose screen time had increased, had higher depression and stress during the COVID-19 pandemic (Meyer et al., 2020).

Shorter sleep duration was associated with worse mental health, i.e., depression, anxiety, and stress. This finding is supported by a population-based study in China, which suggested that individuals with shorter sleep duration had a higher odds ratio of having depressive symptoms (Chen et al., 2020). Furthermore, meeting the sleep guideline is associated with lower stress levels. Unlike other behaviors that have a simple linear relationship with health, a systematic review indicated that both short and long sleep duration had a negative impact on mental health (Zhai et al., 2015). Also, in the Canadian 24-h movement guidelines, both, sleep duration of less than 7 h and longer than 9 h were considered as not meeting the guidelines. In this study, individuals with shorter (< 7 h) and longer sleep duration (> 9 h) accounted for 15.4% and 11.9% of the whole sample, respectively.

The finding that if more of the guidelines were met, less symptoms of depression, anxiety, and stress were reported, supports the hypotheses. These results are consistent with a previous study among adults and older adults showing that meeting any two or all three Canadian 24-h movement guidelines was associated with less frequency of stress, compared with those who met none of the guidelines (Kastelic et al., 2021). In addition, findings from the studies examining the movement behavior combinations and mental health are in accordance with ours. Specifically, a healthier combination of movement behaviors (sufficient PA, low SB, sufficient sleep) was associated with a lower frequency of mental health problems (Ofstedal et al., 2019) and a lower degree of mood disturbance (Hajo et al., 2020) among general adults. This association has important implications considering the wider impact of caregiver's mental health compared with the general population: the mental health of caregivers influences their relationship with the child and has an impact on child's behavior (Prime et al., 2020) and health (Pierce et al., 2020). McCormack et al. found that children whose parents were more anxious went to parks less often and spent more time using or playing computers during the pandemic (McCormack et al., 2020). Promoting a healthy lifestyle, that includes all movement behaviors across the day (high PA, low SB, sufficient sleep), among caregivers may improve their mental health and have a positive impact on the wellbeing of the entire family at this time.

To the best of our knowledge, this is the first study that examined the association between movement behaviors and mental health of caregivers of preschool children in China. The study has used a relatively large sample size from several cities in China. Furthermore, reliable and valid questionnaires were used to measure movement behaviors and mental health. However, the study has some limitations. Firstly, like most studies conducted during the pandemic, the movement behaviors were measured subjectively. Device-based measurements would be

more accurate. Secondly, the use of snowball sampling may have led to selection bias. Furthermore, similar to previous studies (Carroll et al., 2020; Marchetti et al., 2020), more female caregivers provided their responses. Lastly, the cross-sectional design applied in this study cannot be used to identify the cause-and-effect relationship.

5. Conclusions

Having lower SB and longer sleep duration were consistently associated with lower levels of depression, anxiety, and stress, whereas higher PA was associated with a lower level of depression among caregivers. Individuals who met more of the Canadian 24-h movement guidelines had better mental health. These results suggest that promoting a healthy lifestyle (high PA, low SB, and sufficient sleep) may have a positive impact on the mental health of caregivers.

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Declaration of competing interest

The authors declare that they have no conflict of interest.

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