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Compliance with the WHO 24-hour movement guidelines and associations with body weight status among preschool children in Hong Kong

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Novelty bullets: points that summarize the key findings in the work:	Compliance with the WHO 24-hour movement guidelines was extremely low for the early years in Hong Kong., Further evidence is needed to understand the associations between meeting the guidelines and weight status among preschoolers.
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Title: Compliance with the WHO 24-hour movement guidelines and associations with body weight status among preschool children in Hong Kong

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Abstract: This study aimed to investigate the extent to which preschool children in Hong Kong meet the WHO 24-hour movement guidelines and to examine the associations between meeting the guidelines and body weight status. Data from 251 preschoolers (141 boys) aged between three and six years old were analysed. The children wore an activPAL for seven consecutive days to measure physical activity and sleep. Their screen time was reported by their parents using validated questions. Their body weight status was classified as underweight, normal weight or overweight/obese. A total of 2.9% of the preschoolers met all three movement guidelines. Children in compliance with the physical activity, screen time and sleep guidelines accounted for 14.5%, 67.4% and 39.0% of the sample, respectively. There was no significant association between meeting the individual or combined guidelines and body mass index or the odds ratio for being of normal weight. Meeting more guidelines was not associated with body mass index or the odds ratio for being normal weight. Compliance with the 24-hour movement guidelines was extremely low among preschool children in Hong Kong. Meeting the 24-hour movement guidelines was not associated with a favourable weight status among preschoolers.

Novelty

- Compliance with the WHO 24-hour movement guidelines was extremely low for the early years in Hong Kong.
- Further evidence is needed to understand the associations between meeting the guidelines and weight status among preschoolers.

Keywords: physical activity, screen time, sleep, preschoolers, adiposity

Introduction

Physical activity (PA), sedentary behaviour and sleep are individually associated with health-related outcomes in the early years. More specifically, higher PA and longer sleep durations are associated with a lower risk of adiposity, improved motor development, better emotional regulation and higher fitness levels (Carson et al. 2017; Chaput et al. 2017a). More sedentary screen time is associated with a higher risk of adiposity and impaired cognitive development (LeBlanc et al. 2012). However, the recently developed WHO 24-hour movement guidelines highlight the importance to health in the early years of all movement behaviours (PA, sedentary behaviour, sleep) across a 24-hour day (Willumsen and Bull 2020). These guidelines suggest that 'the whole day matters' and provide an approach for investigating the integrated effects of all the movement behaviours on health. After the release of the WHO 24-hour movement guidelines, an increasing number of studies have been conducted to examine compliance with the guidelines, many of them retrospective (i.e., the data were collected prior to the release of the guidelines and did not originally have meeting the guidelines as an aim). Evidence from these studies in several countries (e.g., Canada (Chaput et al. 2017b), the United States (Kracht et al. 2019), Finland (Leppänen et al. 2019), New Zealand (Meredith-Jones et al. 2019)) showed that only a small proportion of preschoolers met all three movement guidelines, and that compliance rates varied greatly across different countries. However, to the best of our knowledge, only one study has been conducted in Asia (China) (Guan et al. 2020), and none among preschoolers in Hong Kong. There is, thus, a need for prospective studies with the specific aim of examining the extent to which preschool children are meeting (or not meeting) the WHO 24-hour movement behaviour guidelines.

Recent studies have explored the associations between meeting the 24-hour movement guidelines and health-related outcomes among preschoolers, with body weight status (e.g., body mass index [BMI],

BMI *z*-score, the odds ratio [OR] for being overweight or obese) being the most common outcome examined (Chaput et al. 2017b; Leppänen et al. 2019; Guan et al. 2020). This is not surprising, given that obesity has become a public health concern for all ages, and at least 38 million children worldwide under five years of age were identified as overweight or obese in 2019 (World Health Organization 2020). The findings have been inconsistent: some studies found no association between meeting the guidelines and BMI *z*-score or body composition (Chaput et al. 2017b; Kracht et al. 2019; Meredith-Jones et al. 2019), whereas others found that meeting the guidelines was associated with lower BMI (Leppänen et al. 2019) and lower OR for being overweight or obese (Guan et al. 2020). The discrepancy across studies may be due to variations in compliance with the guidelines, characteristics (e.g., mean age) of the participants, methods for measuring movement behaviours and the outcome measures chosen. Furthermore, the dose-response relationship between the number of guidelines met and weight status remains unclear (Kracht et al. 2019; Leppänen et al. 2019). It is worth noting that both being underweight and obesity have been recognised as problems in Hong Kong. Specifically, 19.4% of 3-to-6-year-olds were underweight, whereas 13.5% were overweight or obese, according to a city-wide survey (Community Sports Committee of the Sports Commission 2012). Although individuals with extremely high or low BMI may be at higher health risk, attention has been less focused on the issue of being underweight than on obesity. None of the previous studies examining the associations between meeting the 24-hour movement guidelines and body weight status in young children has considered being underweight as an outcome variable. Therefore, this study aimed to: (1) examine compliance with the 24-hour movement guidelines among preschoolers in Hong Kong; (2) examine associations between meeting the 24-hour movement guidelines and body weight status, including being underweight, of normal weight or overweight/obese; and (3) explore the dose-response relationships between meeting the guidelines and body weight status.

Materials and methods

In Hong Kong, preschool education service is provided for children aged between three and six years old, and the majority of young children attend kindergartens. Eight kindergartens were randomly selected based on different socio-economic statuses (SES; three in high SES, one in medium SES and four in low SES), all of which agreed to participate in this study. Invitations were sent to 1,460 parents, of whom 351 agreed to let their child wear an activPAL monitor and completed the survey. Written consent from the parents and assent from the children were obtained. This study was approved by the Research Ethics Committee of Hong Kong Baptist University (Ref. No.: 02160127).

During a school visit, an activPAL monitor was attached to the middle line at the front of the children's thighs by trained research staff. The activPAL monitors were made waterproof by wrapping them in a nitrile sleeve and a 3M Tegaderm transparent dressing (Huang and Lee 2019). The children wore the activPAL (activPAL3 micro or activPAL3C vt) for seven consecutive 24-hour periods. A take-home package was given to the parents, including (1) an information sheet with detailed information about the device and instructions on how to attach and detach it; (2) a log diary for parents to record the times they removed the device and reasons for doing so; (3) additional dressings in case of a need to refit the device; and (4) a questionnaire for parents to complete (e.g., age and sex of their children). The data collection was conducted between March 2018 and May 2019.

The activPAL data were collected in 15-s epochs using a sampling rate of 10 Hz. The data were downloaded using the activPAL software (version 7.2.38) and processed using PALanalysis (v8.11.4.61) to estimate the time spent in sitting/lying, standing and stepping in 15-s epochs. Non-wear time was determined as a period with ≥ 60 min of consecutive zero counts, and days with ≤ 240 min of non-wear time were defined as valid days (Huang and Lee 2019).

PA was defined as all time spent stepping, whereas moderate-to-vigorous-intensity PA (MVPA) was determined as ≥ 1,418 counts/15 s (Janssen et al. 2014). Sleep duration was measured objectively and defined as the period between bedtime and rising time the following day. Bedtime was detected as the last non-sedentary period followed by a period of more than two hours of consecutive sedentary epochs; rising time was detected as the first non-sedentary period after 7:00 AM (Huang and Lee 2019).

Screen time was measured by a parent-reported question based on the Children's Leisure Activities Study Survey questionnaire-Chinese version (CLASS-C) (Huang et al. 2009): 'On average, how much time does your child spend on screen-based sedentary behaviours (e.g., watching TV/DVDs, playing video games, using computers, using tablets and mobile phones) per day?'.

Children's height and weight were measured by trained research staff during a school visit. BMI was calculated as weight (kg)/height (m^2) and categorised as underweight, normal weight or overweight/obese, according to the international age- and sex-specific cut-off points (Cole et al. 2000).

Compliance with the WHO 24-hour movement guidelines was determined as follows: (1) meeting the PA guideline: at least 180 min of total PA (TPA), including 60 min of energetic play (defined as MVPA), (2) meeting the screen time guideline: less than 1 hour of sedentary screen time and (3) meeting the sleep guideline: 10 to 13 hours of sleep (Willumsen and Bull 2020).

Children were included if they had at least one valid day of data and their parents returned the questionnaire (Carson et al. 2019). Descriptive characteristics were presented for children's PA, screen time, sleep and BMI. Compliance with the 24-hour movement guidelines was presented for the whole sample and by different weight statuses. Linear mixed models were used to examine the associations between BMI and (1) meeting or not meeting the guidelines (alone, in combination); and (2) the number of guidelines met, adjusting for children's age and sex, SES and school. Logistic regression models were used to examine the associations between the OR for being of normal weight and (1) meeting or not meeting the guidelines (alone, in combination); and (2) the number of guidelines met, adjusting for children's age and sex, SES and school. Trend analyses were conducted to examine whether meeting more guidelines was associated with BMI and the OR for being of normal weight. All statistical analyses were conducted using the SPSS 26 software (IBM, Armonk, New York). The significance level was set at $p < 0.05$.

Results

Of the 351 participants, 27 withdrew due to personal reasons. Data from 73 children were excluded from data analysis due to lost devices (n = 6), device malfunctions (n = 6) or not having at least one valid day's activPAL data (n = 61). As a result, 251 children (141 boys and 110 girls) were included in the data analysis. Boys had higher TPA (2.5 ± 0.5 vs. 2.3 ± 0.5 hour/day, p = 0.022) and MVPA (2.2 ± 0.5 vs. 2.0 ± 0.5 hour/day, p = 0.012) than girls. There were no differences between the children without activPAL data and children with at least one day of data in terms of sociodemographic factors or movement behaviours. Among these 251 children, the screen time of an additional 78 children was excluded due to it not having been measured (n = 41) or incomplete parent-reported data (n = 37). Therefore, 173 children (97 boys and 76 girls) were included. Based on a retrospective power calculation, the final sample size was adequate to detect an effect size f^2 of 0.08, with a power of 0.80, a p-value of 0.05 and five predictors in a regression model for predicting the associations between meeting guidelines and body weight status. The basic characteristics of the children are presented in Table 1. A total of 19.0% of the children were underweight, and 11.3% were overweight or obese. The children were physically active for 2.4 hours/day on average, of which 2.1 hours were MVPA. They spent an average of 67.8 min and 9.7 hours on screen time and sleep per day, respectively. There were no differences between the included and excluded children in sociodemographic factors or movement behaviours, except that the BMI of the included children was lower than that of the excluded children (15.3 ± 1.4 vs 15.7 ± 1.7).

The proportions of children meeting the 24-hour movement guidelines are presented in Table 2. Specifically, 67.4% of the participants met the screen time guideline, and 39.0% and 14.5% met the sleep and PA guidelines, respectively. Only 2.9% of participants met all three guidelines, and 15.1% met none of the guidelines. Descriptive information of compliance rate by body weight status is shown in Table 2. Table 3 shows the associations between meeting the PA, screen time and sleep guidelines (individual, in combination) and BMI and the OR for being of normal weight. Overall, none of the associations were significant after adjustment for covariates. The dose-response relationships between the number of guidelines met and BMI and OR for being of normal weight were not found.

Discussion

To the best of our knowledge, this is the first study to examine compliance with the 24-hour movement guidelines among preschoolers in Hong Kong. Few preschoolers in Hong Kong met all three movement guidelines (2.9%). No associations were found between meeting the guidelines (alone, in combination) and BMI or the OR for being of normal weight. No dose-response relationship was found between the number of guidelines met and BMI or the OR for being of normal weight.

Among the three guidelines within the 24-hour movement guidelines, the level of compliance with the PA guideline was the lowest (14.5%) in this study. The percentage was similar to that reported in previous studies in Canada (19.3%) (Carson et al. 2019) and Belgium (11.0%) (DeCraemer et al. 2018), but lower than that in the United States (91.5%) (Kracht et al. 2019), Singapore (56.9%) (Chia et al. 2019) or Australia (93.1%) (Cliff et al. 2017). Low levels of PA have also previously been documented as being common in Hong Kong among preschool children (Huang and Lee 2019) and adolescents (Shi et al. 2020). Furthermore, a 12-country study conducted among children aged nine to eleven year olds found that compliance with the Canadian 24-hour movement guidelines for children and youth (Tremblay et al. 2016) varied across countries, with China being the lowest (Roman-Viñas et al. 2016). The reasons for the observed lower levels of PA in Hong Kong young children may be multifaceted. We did additional data analyses and found that the participants were more physically active on weekend days than on weekdays (data not shown). The lower PA during the school days may be due to the limited play areas of kindergartens in Hong Kong. A previous study in Hong Kong found that PA of children in the kindergarten with a larger play space was much higher than that of children in the kindergarten with a limited play space (Louie and Chan 2003). In addition, the Confucian culture and highly competitive education system in Hong Kong made children's academic performance highly emphasized (Lau and Rao 2018). Consequently, preschool-aged children tended to attend extracurricular activities such as English and drawing other than sport-related activities (Lau and Cheng 2014). In addition, parental practices such as safety concerns and lacking time have been identified to discourage PA among preschoolers in Hong Kong (Suen et al. 2015).

Interpretation of compliance to PA guidelines across studies should also consider methodological differences such as different measurements used (e.g., activPAL, ActiGraph (Cliff et al. 2017; DeCraemer et al. 2018; Carson et al. 2019; Kracht et al. 2019), parent-reported questionnaires (Chia et al. 2019), location of monitor placements (e.g., thigh, hip (Cliff et al. 2017; DeCraemer et al. 2018; Kracht et al. 2019), wrist (Carson et al. 2019)), and accelerometer cut-off points utilised. Compared to compliance based on step rate (i.e., 25 steps/15 s for MVPA) calculated from activPAL data, the compliance based on the cut-points of acceleration counts (i.e., ≥ 1418 counts/15 s) applied in this study may overestimate the compliance rate (Huang and Lee 2019). Moreover, the cut-off point for MVPA utilised in the current study was specific to the earlier model of activPAL™ (Janssen et al. 2014), although previous studies found a high level of agreement between estimates of PA between different activPAL models (Klenk et al. 2016; Sellers et al. 2016). There is also no clear consensus about the optimal cut-points using activPAL for classifying MVPA in preschoolers.

For compliance with the screen time guideline (67.4%), our findings showed a lower level than that reported in a study conducted in China (88.2%) (Guan et al. 2020), but a higher level than that in Finland (35.4%) (Leppänen et al. 2019), the United States (14.0%) (Kracht et al. 2019), or Canada (24.4%) (Chaput et al. 2017b). Such discrepancy may be partly explained by cultural-specific differences in parental control. Parents in Eastern Asian countries had more control and supervision over their children, compared with those in Western countries (Pomerantz and Wang 2009). A previous study conducted among preschoolers in Hong Kong found that parental restriction (e.g., not allowing their children watch specific programs, limiting the time of children watching TV) had an impact on their children's screen time-related behaviour (e.g., the frequency of playing computer games) (Wu et al. 2014). Also, another study found that setting a time limit for screen viewing was associated with decreased screen time of primary school children (Lin et al. 2020). Besides, subjective measurement may be another reason for such differences. In all studies, screen time was measured via parent-reported questions or interviews, which may have involved recall bias. The compliance with the sleep guideline in our study (39.0%) was consistent with a previous study conducted among preschoolers in China (29.5%) (Guan et al. 2020), but much lower than that in other countries, such as the United States (86.9%) (Kracht et al. 2019), Canada (83.1%) (Carson et al. 2019), and Australia (93.0%) (Hinkley et al. 2020). Such differences confirm the findings of a cross-cultural study among preschoolers across 14 countries and regions that children in Asian regions had shorter sleep durations than those in predominantly Caucasian countries (Mindell et al. 2013). Furthermore, it was reported that the average nap time among preschoolers in Hong Kong was 1.7 hours (Mindell et al. 2013). Therefore, the level of compliance with the sleep guideline may be underestimated, given that preschoolers' daytime naps were not included in the current study. However, night-time sleep has been commonly used to represent sleep duration among preschoolers (DeCraemer et al. 2018; Kracht et al. 2020).

Previous studies usually compared normal weight with overweight or obese categories, whereas being underweight was not considered (Chaput et al. 2017b; Guan et al. 2020). Consistent with existing estimates in Hong Kong (Community Sports Committee of the Sports Commission 2012), approximately one-fifth of children were classified as underweight in this study. Therefore, the OR for being of normal weight instead of being overweight or obese was used in this study. It was found that there was no association between meeting individual, any combinations of, or all three guidelines and the OR for being of normal weight. These results are consistent with a previous study using other body weight status indicators (i.e., the OR for being overweight or obese) (Chaput et al. 2017b). However, another study conducted in China found that meeting the screen time guideline was associated with a lower OR for being overweight or obese (Guan et al. 2020). The different analytic approach used may be the main reason. Using the OR for being of normal weight as the indicator, the present study compared the normal weight group with both the underweight and overweight/obese groups, whereas the above-mentioned study only compared the normal weight group with the overweight/obese group (Guan et al. 2020).

Consistent with many other studies (Chaput et al. 2017b; Kracht et al. 2019; Meredith-Jones et al. 2019), neither meeting the guidelines individually nor meeting them in combination was associated with BMI in the current study. These findings are in contrast to the associations between meeting the guidelines and adiposity in school-aged children and adolescents (Rollo et al. 2020). The differences in results between preschool-aged and school-aged children can be explained by several reasons. First, it may take time for movement behaviours (i.e., PA, screen time, sleep) to influence children's BMI. A longitudinal study found that meeting all three movement guidelines at 3-5 years old was not associated with BMI *z*-score three years later but was associated with BMI *z*-score six years later (Hinkley et al. 2020). Second, the rapid development and adiposity rebound in early childhood may be another reason (Rolland-Cachera et al. 2006). Even so, one study conducted among children aged between three and six years old in Finland found associations between meeting the guidelines for sleep and those for both PA and sleep with lower BMI (Leppänen et al. 2019). However, the differences between our study and the above-mentioned one (Leppänen et al. 2019), including different sleep measurement methods (activPAL vs parent-reported diary), lower compliance with PA (14.5% vs 84.6%), lower compliance with sleep (39.0% vs 75.7%) and lower average BMI (15.4 vs 21.7) make direct comparison difficult.

No dose-response relationship between meeting the 24-hour movement guidelines and BMI or the OR for being of normal weight was found in the present study. Our findings corroborate those of a previous study that demonstrated that the number of guidelines met did not result in differences in body weight status (Kracht et al. 2019). Leppänen et al. (2019) found that, compared to meeting none or one guideline, meeting two or three guidelines was associated with lower BMI in Finnish children. However, the dose-response relationships between meeting the guidelines and body weight status were not examined in other studies (Chaput et al. 2017b; Meredith-Jones et al. 2019; Guan et al. 2020). The limited evidence so far precludes a definitive conclusion. In order to examine whether the associations between meeting the guidelines and BMI and the OR for being of normal weight were affected by the different inclusion criteria of the number of valid days, sensitivity analyses were conducted (data not shown). No differences were found, except the association between meeting the sleep guideline and the OR for being of normal weight. To be specific, meeting the sleep guideline was associated with a lower OR for being of normal weight when only children with at least three valid days were included ($n = 205$, $OR = 0.42$, 95% CI: 0.22 to 0.77, $p = 0.006$). This result was unexpected and inconsistent with previous studies (Chaput et al. 2017b; Guan et al. 2020). One of these two previous studies used criteria of at least one valid day (Guan et al. 2020), and no underweight children were included in the other study's sample (Chaput et al. 2017b), both of which make comparison difficult.

The strengths of the present study were its use of device-based measurement of PA and sleep, the novelty of the study setting (in Asia) and the uniqueness of reporting the OR for being of normal weight in data analysis. Nevertheless, this study has several limitations. First, consistent with previous studies (Carson et al. 2019; Guan et al. 2020), having activPAL data for at least one day was considered valid in our study, although a more stringent criterion of at least three days may better reflect children's normal behavioural patterns. Second, the sleep duration recommended in the guidelines includes both night-time sleep and daytime naps; however, only night-time sleep was included in this study, which may underestimate the proportion of preschoolers meeting the sleep guideline. Third, nearly half of the children were excluded in the final analysis due to dropouts, invalid or incomplete data, though the final sample size was adequate to detect a small to medium effect size. Finally, the cross-sectional design limits the interpretation of causal relationships.

Conclusion

Overall, only 2.9% of the preschoolers in Hong Kong in the sample met all three 24-hour movement guidelines. Meeting the 24-hour movement guidelines, alone or in combination, was not associated with body weight status among the preschoolers. No dose-response relationship was found between the number of guidelines met and body weight status. Further longitudinal and experimental studies with a national representative sample are needed to examine the benefit of meeting guidelines on body weight status.

Author statements

Competing interests: The authors declare there are no competing interests.

Author contributions: W.Y.H., S.H.S.W., and J.J.R. conceptualized and designed the study; W.Y.H. and J.F. collected data; J.F. performed data analysis under the supervision of W.Y.H. and J.J.R.; J.F.

prepared the first draft, all authors contributed to revising the manuscript and approving the final manuscript.

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References

Carson, V., Ezeugwu, V.E., Tamana, S.K., Chikuma, J., Lefebvre, D.L., Azad, M.B., et al. 2019. Associations between meeting the Canadian 24-hour movement guidelines for the early years and behavioral and emotional problems among 3-year-olds. J. Sci. Med. Sport, **22**(7): 797–802. doi:10.1016/j.jsams.2019.01.003.

Carson, V., Lee, E.Y., Hewitt, L., Jennings, C., Hunter, S., Kuzik, N., et al. 2017. Systematic review of the relationships between physical activity and health indicators in the early years (0-4 years). BMC Public Health, **17**(5): 854. doi:10.1186/s12889-017-4860-0.

Chaput, J.P., Gray, C.E., Poitras, V.J., Carson, V., Gruber, R., Birken, C.S., et al. 2017a. Systematic review of the relationships between sleep duration and health indicators in the early years (0-4 years). BMC Public Health, **17**(5): 855. doi:10.1186/s12889-017-4850-2.

Chaput, J.P., Colley, R.C., Aubert, S., Carson, V., Janssen, I., Roberts, K.C., et al. 2017b. Proportion of preschool-aged children meeting the Canadian 24-hour movement guidelines and associations with adiposity: Results from the Canadian health measures survey. BMC Public Health, **17**(Suppl 5): 829. doi:10.1186/s12889-017-4854-y.

Chia, M.Y.H., Tay, L.Y., and Chua, T.B.K. 2019. Quality of life and meeting 24-h WHO guidelines among preschool children in Singapore. Early Child. Educ. J. **48**(3): 313–323. doi:10.1007/s10643-019-00987-9.

Cliff, D.P., McNeill, J., Vella, S.A., Howard, S.J., Santos, R., Batterham, M., et al. 2017. Adherence to 24-hour movement guidelines for the early years and associations with social-cognitive development among Australian preschool children. BMC Public Health, **17**(Suppl 5): 857. doi:10.1186/s12889-017-4858-7.

Cole, T.J., Bellizzi, M.C., Flegal, K.M., and Dietz, W.H. 2000. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ, **320**(7244): 1240. doi:10.1136/bmj.320.7244.1240.

Community Sports Committee of the Sports Commission. 2012. Healthy Exercise For All Campaign - Physical Fitness Test For The Community. Available from https://www.lcsd.gov.hk/en/healthy/physical_fitness_test/common/physical_fitness_test/download/SummaryReport_en.pdf. [Accessed 10 October 2020.]

DeCraemer, M., McGregor, D., Androutsos, O., Manios, Y., and Cardon, G. 2018. Compliance with 24-h movement behaviour guidelines among Belgian pre-school children: The ToyBox-study. Int. J. Environ. Res. Public Health, **15**(10): 1–10. doi:10.3390/ijerph15102171.

Guan, H., Zhang, Z., Wang, B., Okely, A.D., Tong, M., Wu, J., et al. 2020. Proportion of kindergarten children meeting the WHO guidelines on physical activity, sedentary behaviour and sleep and associations with adiposity in urban Beijing. BMC Pediatr. **20**(1): 1–9. doi:10.1186/s12887-020-1969-6.

Hinkley, T., Timperio, A., Watson, A., Duckham, R.L., Okely, A.D., Cliff, D., et al. 2020. Prospective associations with physiological, psychosocial and educational outcomes of meeting Australian 24-Hour Movement Guidelines for the Early Years. Int. J. Behav. Nutr. Phys. Act. **17**(1): 1–12. doi:10.1186/s12966-020-00935-6.

Huang, W.Y., and Lee, E.Y. 2019. Comparability of activPAL-based estimates of meeting physical activity guidelines for preschool children. Int. J. Environ. Res. Public Health, **16**(24): 5146. doi:10.3390/ijerph16245146.

Huang, Y.J., Wong, S.H.S., and Salmon, J. 2009. Reliability and calidity of the modified Chinese version of the Children's Leisure Activities Study Survey (CLASS) questionnaire in assessing physical activity among Hong Kong children. Pediatr. Exerc. Sci. **21**(3): 339–353. doi:10.1123/pes.21.3.339.

Janssen, X., Cliff, D.P., Reilly, J.J., Hinkley, T., Jones, R.A., Batterham, M., et al. 2014. Validation and calibration of the activPAL™ for estimating METs and physical activity in 4-6 year olds. J. Sci. Med. Sport, **17**(6): 602–606. doi:10.1016/j.jsams.2013.10.252.

Klenk, J., Büchele, G., Lindemann, U., Kaufmann, S., Peter, R., Laszlo, R., et al. 2016. Concurrent validity of activPAL and activPAL3 accelerometers in older adults. J. Aging Phys. Act. **24**(3): 444–450. doi:10.1123/japa.2015-0178.

Kracht, C.L., Webster, E.K., and Staiano, A.E. 2019. Sociodemographic differences in young children meeting 24-hour movement guidelines. J. Phys. Act. Health, **16**(10): 908–915. doi:10.1123/jpah.2019-0018.

Kracht, C.L., Webster, E.K., and Staiano, A.E. 2020. Relationship between the 24-hour movement guidelines and fundamental motor skills in preschoolers. J. Sci. Med. Sport, **23**(12): 1185–1190. doi:https://doi.org/10.1016/j.jsams.2020.06.021.

Lau, E.Y.H., and Cheng, D.P.W. 2014. An exploration of the participation of kindergarten-aged Hong Kong children in extra curricular activities. J. Early Child. Res. **14**(3): 294–309. doi:10.1177/1476718X14552873.

Lau, C., and Rao, N. 2018. Early childhood education in Hong Kong. *In* Handbook of International Perspectives on Early Childhood Education. *Edited by* J.L. Roopnarine, J.E. Johnson, S.F. Quinn, and M.M. Patte. Routledge. pp. 149–161.

LeBlanc, A.G., Spence, J.C., Carson, V., Connor Gorber, S., Dillman, C., Janssen, I., et al. 2012. Systematic review of sedentary behaviour and health indicators in the early years (aged 0-4 years). Appl. Physiol. Nutr. Metab. **37**(4): 753–772. doi:10.1139/h2012-063.

Leppänen, M.H., Ray, C., Wennman, H., Alexandrou, C., Sääksjärvi, K., Koivusilta, L., et al. 2019. Compliance with the 24-h movement guidelines and the relationship with anthropometry in Finnish preschoolers: The DAGIS study. BMC Public Health, **19**(1): 1–8. doi:10.1186/s12889-019-7967-7.

Lin, Y.-C., Tsai, M.-C., Strong, C., Hsieh, Y.-P., Lin, C.-Y., and Lee, C.S.C. 2020. Exploring mediation roles of child screen-viewing between parental factors and child overweight in Taiwan.

Int. J. Environ. Res. Public Health, **17**(6): 1878. doi:10.3390/ijerph17061878.

Louie, L., and Chan, L. 2003. The use of pedometry to evaluate the physical activity levels among preschool children in Hong Kong. Early Child Dev. Care. **173**(1): 97–107. doi:10.1080/0300443022000022459.

Meredith-Jones, K., Galland, B., Haszard, J., Gray, A., Sayers, R., Hanna, M., et al. 2019. Do young children consistently meet 24-h sleep and activity guidelines? A longitudinal analysis using actigraphy. Int. J. Obes. **43**(12): 2555–2564. doi:10.1038/s41366-019-0432-y.

Mindell, J.A., Sadeh, A., Kwon, R., and Goh, D.Y.T. 2013. Cross-cultural differences in the sleep of preschool children. Sleep Med. **14**(12): 1283–1289. doi:https://doi.org/10.1016/j.sleep.2013.09.002.

Pomerantz, E.M., and Wang, Q. 2009. The role of parental control in children's development in Western and East Asian countries. Curr. Dir. Psychol. Sci. **18**(5): 285–289. doi:10.1111/j.1467-8721.2009.01653.x.

Rolland-Cachera, M.F., Deheeger, M., Maillot, M., and Bellisle, F. 2006. Early adiposity rebound: causes and consequences for obesity in children and adults. Int. J. Obes. **30**(4): S11–S17. doi:10.1038/sj.ijo.0803514.

Rollo, S., Antsygina, O., and Tremblay, M.S. 2020. The whole day matters: Understanding 24-hour movement guideline adherence and relationships with health indicators across the lifespan. J. Sport Health Sci. doi:https://doi.org/10.1016/j.jshs.2020.07.004.

Roman-Viñas, B., Chaput, J.P., Katzmarzyk, P.T., Fogelholm, M., Lambert, E.V., Maher, C., et al. 2016. Proportion of children meeting recommendations for 24-hour movement guidelines and associations with adiposity in a 12-country study. Int. J. Behav. Nutr. Phys. Act. **13**(1): 1–10. doi:10.1186/s12966-016-0449-8.

Sellers, C., Dall, P., Grant, M., and Stansfield, B. 2016. Agreement of the activPAL3 and activPAL for characterising posture and stepping in adults and children. Gait Posture, **48**: 209–214. doi:https://doi.org/10.1016/j.gaitpost.2016.05.012.

Shi, Y., Huang, W.Y., Sit, C.H.P., and Wong, S.H.S. 2020. Compliance with 24-hour movement guidelines in Hong Kong adolescents: Associations with weight status. J. Phys. Act. Health, **17**(3): 287–292. doi:10.1123/jpah.2019-0230.

Suen, Y., Cerin, E., and Wu, S. 2015. Parental practices encouraging and discouraging physical activity in Hong Kong Chinese preschoolers. J. Phys. Act. Health, **12**(3): 361–369. doi:10.1123/jpah.2013-0123.

Tremblay, M.S., Carson, V., Chaput, J.-P., Gorber, S.C., Dinh, T., Duggan, M., et al. 2016. Canadian 24-hour movement guidelines for children and youth: An integration of physical activity, sedentary behaviour, and sleep. Appl. Physiol. Nutr. Metab. **41**(6 (Suppl. 3)): S311-27. doi:10.1139/apnm-2016-0151.

Willumsen, J., and Bull, F. 2020. Development of WHO guidelines on physical activity, sedentary behavior, and sleep for children less than 5 years of age. J. Phys. Act. Health, **17**(1): 96–100. doi:10.1123/jpah.2019-0457.

World Health Organization. 2020. Obesity and Overweight. Available from https://www.who.int/en/news-room/fact-sheets/detail/obesity-and-overweight. [Accessed 10 October 2020.]

Wu, C.S.T., Fowler, C., Lam, W.Y.Y., Wong, H.T., Wong, C.H.M., and Yuen Loke, A. 2014. Parenting approaches and digital technology use of preschool age children in a Chinese community. Ital. J. Pediatr. **40**(1): 1–8. doi:10.1186/1824-7288-40-44

Table 1. Characteristics of the participants

	Whole sample		Children with complete data#	
	N	Mean (SD) or n (%)	N	Mean (SD) or n (%)
Age (years)	248	5.0 (0.8)	173	5.1 (0.8)
Boys, n (%)	251	141 (56.2%)	173	97 (56.1%)
BMI	249	15.4 (1.5)	172	15.3 (1.4)
Body weight status, n (%)	247		172	
Underweight		47 (19.0%)		34 (19.8%)
Normal weight		172 (69.6%)		119 (69.2%)
Overweight or Obese		28 (11.3%)		19 (11.0%)
SES, n (%)	251		173	
Low		154 (61.4%)		121 (69.9%)
Medium/High		97 (38.6%)		52 (30.1%)
Movement behaviors				
Number of valid days	251	4.7 (1.9)	173	4.8 (1.9)
TPA (hour/day)	251	2.4 (0.5)	173	2.4 (0.5)
MVPA (hour/day)	251	2.1 (0.5)	173	2.1 (0.5)
Sleep (hour/day)	251	9.7 (0.9)	173	9.8 (0.9)
Screen time (min/day)	173	67.8 (51.7)	173	67.8 (51.7)

Abbreviations: BMI, body mass index; SES, socio-economic status; TPA, total physical activity; MVPA, moderate-to-vigorous-intensity physical activity.

Children who had both valid activPAL data (for physical activity and sleep) and parent-reported screen time.

Table 2. Compliance with the 24-hour movement guidelines

	All (N = 172)	Underweight (N = 34)	Normal weight (N = 119)	Overweight/obese (N = 19)
PA	25 (14.5%)	3 (8.8%)	21 (17.6%)	1 (5.3%)
Screen time	116 (67.4%)	20 (58.8%)	83 (69.7%)	13 (68.4%)
Sleep	67 (39.0%)	16 (47.1%)	42 (35.3%)	9 (47.4%)
PA + screen time	20 (11.6%)	2 (5.9%)	17 (14.3%)	1 (5.3%)
PA + sleep	6 (3.5%)	1 (2.9%)	4 (3.4%)	1 (5.3%)
Screen time + sleep	41 (23.8%)	10 (29.4%)	25 (21.0%)	6 (31.6%)
All three	5 (2.9%)	1 (2.9%)	3 (2.5%)	1 (5.3%)
None	26 (15.1%)	7 (20.6%)	16 (13.4%)	3 (15.8%)
One	89 (51.7%)	16 (47.1%)	63 (52.9%)	10 (52.6%)
Two	52 (30.2%)	10 (29.4%)	37 (31.1%)	5 (26.3%)

Abbreviations: PA, physical activity.

Note. Physical activity guideline: ≥ 180 min of total physical activity, and ≥ 60 min of moderate-to-vigorous-intensity physical activity; screen time guideline: ≤ 60 min of screen time; sleep guideline: 10 hours ≤ sleep duration ≤ 13 hours.

Table 3. Associations between meeting guidelines and body weight status

		BMI		OR for being normal weight	
Meet guidelines	N	β (95% CI)	p value	OR (95% CI)	p value
Meeting (vs. not meeting) individual guideline					
At least PA	247	–0.06 (–0.66 to 0.54)	0.848	2.57 (0.92 to 7.20)	0.072
At least screen time	172	–0.05 (–0.53 to 0.42)	0.823	1.32 (0.66 to 2.64)	0.432
At least sleep	247	–0.05 (–0.45 to 0.35)	0.794	0.64 (0.36 to 1.11)	0.112
Meeting (vs. not meeting) specific combinations					
At least PA + screen time	172	–0.05 (–0.75 to 0.64)	0.882	2.92 (0.80 to 10.62)	0.104
At least PA + sleep	247	0.45 (–0.64 to 1.54)	0.419	1.25 (0.24 to 6.46)	0.786
At least screen time + sleep	172	–0.22 (–0.74 to 0.30)	0.407	0.55 (0.26 to 1.17)	0.119
All three	172	0.54 (–0.77 to 1.85)	0.417	0.69 (0.11 to 4.31)	0.687
Number of guidelines met					
Meet none		Reference		Reference	
Meet one		0.11 (–0.54 to 0.75)	0.746	1.49 (0.59 to 3.74)	0.399
Meet two		–0.25 (–0.95 to 0.45)	0.477	1.39 (0.51 to 3.83)	0.521
Meet three		0.51(–0.89 to 1.92)	0.472	0.93 (0.13 to 6.69)	0.943
Trend analysis	172	–0.04 (–0.39 to 0.23)	0.599	1.07 (0.68 to 1.69)	0.774

Linear mixed models, logistic regression models, and trend analyses were adjusted for sex, age, SES, schools.

Abbreviations: BMI, body mass index; OR, odds ratio; PA, physical activity; β, unstandardized beta coefficient; 95% CI, 95% confidence interval.