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## **Time use clusters in children and their associations with sociodemographic factors**

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### **Abstract**

**Background:** Understanding patterns of time use of children is helpful in developing target-tailored intervention. The purpose of this study was to investigate the clustering of sedentary behaviours and physical activity in Chinese children and to examine the associations between sociodemographic factors and the time use clusters.

**Methods:** Cluster analysis was conducted among 1,013 Chinese children aged 9-13 years (49.5% boys) recruited in a cross-sectional survey study. Physical activity and sedentary behaviours were assessed using a validated questionnaire. Differences in socio-demographic variables were compared across the clusters.

**Results:** Five clusters were identified for boys and girls, respectively. For boys, the five clusters were labelled “*Actives*” (9.1%), “*Inactives*” (59.4%), “*Sedentary homeworkers*” (4.7%), “*Sedentary TV viewers*” (16.6%), and “*Sedentary games players*” (10.2%). For girls, they were labelled “*Actives*” (11.9%), “*Uninvolved inactives*” (39.6%), “*Sedentary homeworkers*” (11.3%), “*Sedentary TV viewers*” (8.5%), and “*Sedentary Games players*” (28.8%). Only parental education was found to differ across the five clusters in boys.

**Conclusions:** The findings demonstrated that sedentariness in youth is multidimensional and it could not be accurately represented by singular behaviour. There is a potential need when designing specific interventions to reduce a group of sedentary behaviours to tailor these interventions for specific clusters.

## **Introduction**

Prolonged sedentary time and lack of regular physical activity (PA) are important modifiable behaviours that have an impact on health outcomes in youth.<sup>1,2</sup> Sedentary behaviour is traditionally studied as physical inactivity.<sup>3</sup> However, an international consensus has been reached recently on defining sedentary behaviour as a distinct behaviour of PA.<sup>4</sup> In other words, children can be physically active while simultaneously engaging in a high number of sedentary pursuits.<sup>5</sup> The diversity and variability of time use patterning in children suggests that a combined instead of an isolated activity profile should be examined.<sup>6,7</sup>

Of further concern, the associations between sedentary behaviours and health outcomes may differ across various types of sedentary pursuits. For example, screen-based sedentary behaviour, compared with the total sedentary time, was more consistently shown to be associated with the markers of adiposity.<sup>8,9</sup> In terms of cardiometabolic risk, the type of sedentary behaviour may be more important than the total amount.<sup>10</sup> These associations appear to be partly related to snack or beverage consumption alongside TV viewing or the engagement with other media.<sup>1</sup> For example, a systematic review suggested that for young people there was consistent evidence showing that higher levels of TV viewing were associated with a less healthful diet, such as greater intake of energy-dense snacks and sugar sweetened beverages.<sup>11</sup> Experimental studies also showed preliminary evidence that screen-based behaviours in the absence of food advertising led to the increased acute energy intake in a laboratory setting.<sup>12</sup> Given that health-related behaviours such as PA and various types of sedentary behaviours may combine in complex ways in children,<sup>13</sup> understanding how these behaviours cluster together could be used to identify individuals at certain risk and to tailor cluster-specific interventions.<sup>14</sup>

Data-driven methods, such as cluster analysis, provide a rich understanding of behavioural patterns by separating individuals into exclusive groups that share similar characteristics.<sup>13,15</sup> Cluster analysis has been widely applied in nutrition as well as PA research in recent decades. A recent systematic review examining time use clusters among adolescents has found only one relatively consistent pattern of time use clusters in adolescent boys, i.e. a so-called “technoactive cluster,” which means the co-occurrence of high levels of PA and high levels of screen time.<sup>14</sup> However, only one study included in this review was conducted among Asian youth. Furthermore, few studies have examined academic activities such as doing homework. Academic achievement is highly valued in Chinese society; it is not surprising that a previous study found that study-related activities, such as homework and reading, occupied most of Chinese children’s after-school time.<sup>16</sup> This was particularly the case for girls.<sup>17</sup> Even the ethnic minorities (e.g. Asian) in western countries were more likely to be identified in a study-related cluster.<sup>14</sup> Therefore, the purpose of this study was to investigate the clustering of sedentary behaviours and PA in Chinese children and to examine the associations between sociodemographic factors and the time use clusters.

## **Methods**

### **Participants and procedures**

Schoolchildren in grades 4-6 were recruited in 2007 from three major geographical regions, that is Hong Kong Island, Kowloon and the New Territories in Hong Kong, using the stratified cluster sampling method. A total of 15 schools were selected: 5 from high socio-economic status (SES), 5 from medium SES and 5 from low SES districts. At each school, one class from each grade from 4 to 6 was randomly selected. All students in the selected class were invited to participate in the study. Written descriptions were distributed to the parents by school teachers. Parental consent forms were obtained from 1,013 children aged 9-13

years (49.5% boys) (52% of eligible). The study was approved by the Survey and Behavioural Research Ethics Committee of the Chinese University of Hong Kong.

The administration of the questionnaire survey was performed in physical education classes or during recess. The investigator was present when a group of students self-completed the questionnaire, but did not interfere in the response process. After completion of the questionnaire, the children's body weights and heights were measured by trained assessors. For the questions answered by parents, children were asked to return the completed questionnaire to the liaison teacher at each participating school.

## **Measures**

### *Socio-demographics and anthropometry*

The children reported their date of birth, gender, grade, and the number of siblings at home. Each child was also asked whether or not (s)he currently participated in any school sports teams. Body mass index (BMI) was calculated to determine the weight status of each participating child. Overweight and obesity was classified according to the age- and gender-specific criteria.<sup>18</sup> The responding parent reported his or her education level and that of his/her partner based on categories classified in Hong Kong Digest of Statistics 2011 (<http://www.censtatd.gov.hk/hkstat/sub/sp140.jsp?productCode=B1010003>), ranging from '1, below kindergarten' to '8, postgraduate course.' Marital status (married, widowed, divorced/separated, and unmarried) and occupation of the parents was also collected in the questionnaire. For purpose of analysis, marital status was categorized as married or not, and proportion of non-employment of the parents was presented.

### *PA and sedentary behaviours*

Children's PA and sedentary behaviours were measured by a validated questionnaire, namely the Children's Leisure Activities Study Survey - Chinese Version (CLASS-C), which consisted of a checklist of 31 physical activities (by excluding 3 activities from the original CLASS questionnaire and including 4 popular activities in Hong Kong) and 13 sedentary pursuits.<sup>19</sup> The reliability and validity of the CLASS-C questionnaire has been reported elsewhere. Briefly, it demonstrated substantial test-retest reliability (ICC=0.71) and acceptable validity when compared with the ActiGraph accelerometer ( $r=0.48$  for girls and  $0.25$  for boys) in assessing weekly PA. The physical activities included in the questionnaire were either of moderate or vigorous intensity according to the established compendium for youth.<sup>20</sup> The time spent in moderate-to-vigorous PA (MVPA) and each sedentary pursuit daily was then calculated by averaging the weekly amount.

Two criteria were used to determine whether or not a behaviour was to be included in the cluster analysis:<sup>21</sup> (i) at least 10% of the sample reporting the participation and (ii) the mean duration of a behaviour being at least 10 min/ day for the whole sample. Behaviours of every short mean duration or low prevalence were excluded as they were considered unlikely to be significantly meaningful in the promotion of active lifestyles.<sup>21</sup> Based on the above criteria, the following activities were excluded from the final analysis: playing handball, baseball, golf, rugby, judo, karate and tae kwon do, playing with toys indoors, doing arts and crafts, playing cards, playing musical instruments, and traveling to school by car. Furthermore, sitting and talking as well as talking on the phone were grouped together as "socializing behaviour" because they represent conceptually similar behaviours.<sup>21</sup> The total sedentary time was calculated by summing up the self-reported time spent in doing homework, watching TV, playing electronic games, using the Internet, reading, listening to music, and engaging in socializing behaviour. Duration estimates exceeding 10 h/ day for any given sedentary pursuit were considered reporting errors and, thus, were excluded

from the analyses. The proportion of the cases excluded was 6.8% for the girls and 5.4% for the boys. The analyses of the excluded data revealed no differences in age and body height. However, the excluded girls had higher BMI than the included girls in the final analysis (19.0 vs. 17.9,  $P < 0.05$ ), indicating that girls with higher BMI were more likely to over-report. Thus, the final sample for analysis consisted of 471 boys and 480 girls.

### **Data analysis**

The statistical analyses were performed using SPSS for Windows version 22.0. Gender differences in the sociodemographic variables and time spent in PA and sedentary behaviours were determined using the  $t$  tests. To characterize the sedentary behaviours and PA, a cluster analysis was employed to identify the groups of children with similar patterns. Variables were converted to z-score before the cluster analysis. A two-stage analysis was separately conducted for the boys and girls due to two major reasons: firstly, gender-specific patterns have been suggested in the literature;<sup>14</sup> and secondly, boys have been consistently shown to be physically active than girls.<sup>22</sup> First, an agglomerative hierarchical cluster analysis using Ward's method with squared Euclidean distance was performed to determine the potential number of clusters. Second, the seven sedentary behaviours and MVPA were plotted for the potential cluster solutions, and comparisons were made in the pattern profiles of cluster means among the sub-samples. The number of clusters was then determined based on the pattern characteristics of elevation in mean level, the dispersion of the profile's scores around their average, and conceptual considerations.<sup>23</sup> The activity profiles were assessed separately on weekday and weekend days but the results were not significantly different. The results were then combined. To explore the associations of the sociodemographic factors (age, body weight status, parental education, marital status, occupation, siblings, and sports team participation) with cluster membership, analysis of variance (ANOVA) and chi-square were performed where appropriate. Alpha level was set at  $< 0.05$ .

## Results

Boys and girls had similar age (mean age =11 years) and body height. 26.0% of the boys and 13.0% of the girls were classified as being overweight and obese. On average, boys and girls spent more than one hour per day in MVPA (mean  $\pm$  SD in boys and girls:  $78 \pm 57$  vs  $79 \pm 56$ , NS). Boys invested less time in doing homework ( $55 \pm 64$  vs  $65 \pm 63$  min·d<sup>-1</sup>,  $P < 0.05$ ), socializing behaviours ( $16 \pm 37$  vs  $27 \pm 47$  min·d<sup>-1</sup>,  $P < 0.05$ ) and reading ( $14 \pm 30$  vs  $18 \pm 28$  min·d<sup>-1</sup>,  $P < 0.05$ ), but more minutes in playing electronic games ( $38 \pm 50$  vs  $22 \pm 36$  min·d<sup>-1</sup>,  $P < 0.05$ ), than girls.

The correlation matrix for the 7 sedentary behaviours and PA were tested. All relations were positive and generally low with only one correlation between ‘*Playing electronic games*’ and ‘*Using Internet*’ being slightly greater than 0.3. The low inter-correlations among the variables suggested that the associations were unlikely to influence the clustering procedure. The hierarchical cluster dendrograms indicated that there were 4 or 5 clusters in both boys and girls. After comparing the two solutions in pattern characteristics and scatter in values, the five-cluster solution emerged as tenable for both boys and girls. The average time for PA and the seven sedentary pursuits for the five clusters of boys and girls were presented in Table 1 and Table 2, respectively. Figures 1 and 2 show the cluster profiles expressed in z-scores.

For boys, the five clusters were labelled “*Actives*” (n=43, 9.1%), “*Inactives*” (n=280, 59.4%), “*Sedentary homeworkers*” (n=22, 4.7%), “*Sedentary TV viewers*” (n=78, 16.6%), and “*Sedentary Games players*” (n=48, 10.2%). Cluster 1 “*Actives*” comprised boys who, compared with their peers, reported the highest PA levels and lowest level of sedentary behaviours. All the boys in Cluster 1 reached the recommended PA of one hour per day. Only 7% of them engaged in screen time for more than two hours per day. Boys’ cluster 2 “*Inactives*” spent less time in PA but having lower sedentary behaviours compared with the



three sedentary clusters. Approximately half of Cluster 2 boys met the PA recommendation. Cluster 3 “*Sedentary homeworkers*” consisted of boys whose sedentary behaviours were characterized by the highest levels of homework compared with their peers (3.5 hours per day). None of them watched TV for over two hours per day. Cluster 4 “*Sedentary TV viewers*” comprised boys whose sedentary time was dominated by high levels of TV viewing. Over 60% of Cluster 3 boys reported participation in sufficient PA. Boys’ Cluster 5 “*Sedentary Games players*” exhibited the highest level of playing electronic games (126 min·d<sup>-1</sup>) compared with their peers. Over 90% of boys in Cluster 4 and Cluster 5 engaged in excessive time spent in screen-based behaviours. Boys in Cluster 1 had more highly educated parents than those in Cluster 5. A majority of boys in Cluster 1 were currently engaged in school sport teams.

The clustering for girls shared both common and unique characteristics with the boys’ profiles. Girls’ Cluster 1 “*Actives*” was characterized as having the highest level of PA and a lower level of sedentary behaviours compared with the other clusters. All the Cluster 1 girls reached the recommended PA and one fifth of them spent more than two hours per day in screen time. Cluster 2 “*Uninvolved inactives*” comprised girls who had lower PA compared with the “*Actives*” cluster and the other two sedentary clusters (3 and 4), and the lowest sedentary behaviours compared with the other clusters. Only 1% of the girls in this cluster engaged in excessive screen time. About 11% of the girls were labelled Cluster 3 “*Sedentary homemaker*”, which was characterized by the highest levels of doing homework. A majority (70.4%) of the girls met the PA recommendation; however, two thirds of them spent at least two hours per day in screen time. Girls’ Cluster 4, labelled “*Sedentary TV viewers*,” comprised girls whose leisure time was dominated by high levels of TV viewing. Half of them reported participation in the recommended PA level and all of them were excessive screen time consumers. Girls’ Cluster 5, labelled “*Sedentary socializers*,” comprised girls who reported the highest level of socializing behaviours compared with their peers.

Approximately half of them met the recommended PA of one hour per day and over 70% of them engaged in screen time for over two hours per day.

Among boys, parental education level was the only factor associated with cluster membership. The “*Secondary Games players*” cluster comprised parents with lower education level compared with the “*Actives*” cluster. Among girls, none of the sociodemographic variables was associated with cluster membership.

## **Discussion**

### **Main findings of this study**

This study identified five gender-specific clusters for Chinese children. The clusters were named based on the highest cluster-specific time use variable or using qualitative labels to describe the cluster-specific pattern.<sup>14</sup> Consistent with the previous studies conducted in Caucasian children and adolescents, low inter-correlations were found among a variety of sedentary pursuits, which demonstrated that sedentariness in the youth is multidimensional and could not be accurately represented by singular behaviour.<sup>23,24</sup> The findings suggested that there is a potential need to design interventions strategies tailored to specific behavioural clusters.

### **What is already known on this topic?**

Previous research has shown that health-related behaviours (e.g. PA and sedentary behaviour) do not occur in isolation. Children failing to achieve one behavioural recommendation were less likely to meet the other one.<sup>25</sup> Clustering of children who share similar time use profiles seems to differ across gender and country.<sup>14</sup> Despite the discrepancy, a systematic review examining the time use clusters among adolescents identified a most common cluster profile in the published studies, i.e. “technoactive”, which was characterized by the co-occurrence of

high levels of both PA and screen time.<sup>14</sup> There have been no consistent correlates of time use clusters reported in the literature except for gender.<sup>14</sup> A more recent review looking at broader health risk behaviours among children and adolescents, however, indicated that a higher level of parental education was associated with higher PA participation and lower engagement in TV or screen time.<sup>13</sup> With regard to Chinese children, a national survey has found that they had different leisure time behaviours compared with their counterparts in western countries, as their after-school time was mostly occupied by study-related activities.<sup>16</sup>

### **What this study adds?**

The clustering profiles identified in this study shared some common patterns with those found in Caucasian children and adolescents but also identified some unique ones. The typical “technoactive cluster,” which has been widely reported in boys in western countries<sup>7</sup> and the other Asian regions,<sup>26</sup> did not emerge in this study. For Chinese boys, two distinct clusters (boys’ clusters 4 and 5) were identified as having high screen time; one was characterized by excessive engagement in TV viewing and the other by high amount of time spent playing electronic-games. Their PA levels were not different from those in Cluster 2 “Uninvolved inactives” and Cluster 3 “Sedentary homeworkers,” but were lower than for boys in Cluster 1. Due to the high amount of screen time, these two clusters could be considered at an increased risk in terms of cardiometabolic health.<sup>27</sup> The findings support the notion that no systematic negative association exists between health enhancing PA and sedentary time

Another pertinent finding of this study is that academic activity is one of the key components of sedentary behaviours for Chinese children, particularly for Chinese girls. In the current study, over 40% of the children spent more than one hour per day doing homework in

non-school time, which was higher than that reported in the U.K.,<sup>21</sup> but lower than that in Singapore.<sup>26</sup> However, the study conducted among Singaporean children used a 24-hour recall to measure PA and sedentary behaviour, which might explain the higher study time recorded.<sup>26</sup> Similar to a citywide survey of Hong Kong primary school children,<sup>17</sup> screen-based behaviour is still the most prevalent sedentary behaviour for children. However, only a small proportion of the boys (16.6%) and the girls (8.5%) were identified as TV consumers, and few boys outside this cluster engaged in screen time of an amount exceeding the recommended level.<sup>28</sup> For girls, a high amount of screen time seems to be prevalent in the other two sedentary clusters (“Sedentary homeworkers” and “Sedentary socializers”). Similar patterns have also been reported among UK boys and girls.<sup>21</sup> It seems that girls are more likely than boys to exhibit a co-occurring pattern rather than a singular sedentary behaviour.

The only significant correlate of the behavioural clusters was parental education level for boys. Parental education has been generally regarded as the indicator of SES.<sup>29</sup> Children from lower SES families may get less financial support for healthier behavioural choices.<sup>7,29</sup> Consistent with the literature, a higher level of parental education was associated with higher PA participation, whereas lower parental education may equate with more engagement in TV or screen time for their child.<sup>13</sup> Providing parental education or necessary support for these boys may be of importance in future interventions to reduce their screen time, in particular the time spent playing electronic games for Chinese boys. Qualitative studies may be helpful to further explore the potential reasons mediating the relationship between parental education and the time use clusters.

Interventions to increase PA and reduce sedentary time in children and adolescents have demonstrated small effect size and last for only a short period<sup>30,31</sup> The multifaceted sedentary clusters identified in this study have implications for future interventions among Chinese

children, i.e. profile-specific and gender-specific strategies are warranted. Given the academic pressure in Chinese society, it is difficult and unrealistic to request a reduction in children's study time. More important, the impact of a sedentary lifestyle on cardiometabolic health outcomes may mostly depend on the types of sedentary behaviour.<sup>27</sup> It is screen-based behaviour rather than the other types of sedentary behaviours that have been found to be associated with obesity and with markers of cardiometabolic disease risk.<sup>1</sup> Limiting screen time could be a meaningful way to reduce total sedentary time across the whole sedentary clusters for girls but may not be so for boys. For boys labelled sedentary homeworkers, screen time does not contribute substantially to overall sedentary time. The success of interventions to reduce sedentary time depends on the type of activity replacing it and, thus, may need to target a group of behaviours.<sup>21</sup> Research has shown that re-allocating 30 minutes per day of sedentary time to light-intensity was beneficial for biomarkers of cardiovascular disease risk.<sup>32</sup> For girls in the social cluster type, specific strategies to replace group activities and involve their peers may be promising.

### **Limitations of this study**

Low engagement clusters in both PA and any type of sedentary behaviours were found in this study in particular for the girls. Similar results have also been observed in other studies.<sup>24,33</sup> Both of these studies asked participants to self-report their PA and sedentary behaviours. It may be that the girls in Cluster 2 under-reported their participation in various activities or the activities they were involved were not included in the questionnaire. Using 24-hour recall has been suggested to capture a full range of activities and thus reduce the likelihood of underreporting, but studies not applying this method did not observe any low-engagement clusters either.<sup>14</sup> Although the CLASS-C questionnaire used in this study has been validated in Chinese children in Hong Kong,<sup>19</sup> it is still possible that some activities cannot be captured in this instrument, such as stair climbing, sporadic activities, and the other sedentary pursuits.

Future studies should also include objective measures of PA and sedentary behaviours which may be helpful for better understanding the time use patterns in children.

## **Conclusion**

Chinese children demonstrated a variety of activity profiles. The finding that children's lifestyle behaviour is predominated by one activity suggested that there is a potential need when designing specific interventions to reduce a group of sedentary behaviours to tailor these interventions for specific clusters.

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