

Combined Patterns Of Physical Activity And Screen-Related Sedentary Behavior Among Chinese Adolescents And Their Correlations With Depression, Anxiety And Self-Injurious Behaviors

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Background and purpose: There are increasing concern about independent associations between physical activity, screen-based sedentary behavior (SSB), and psychological problems, but only a few studies have attempted to explore combined patterns of physical activity and SSB in adolescents and their correlations with psychological problems. This study was aimed at identifying combined patterns of moderate-to-vigorous physical activity (MVPA) and SSB and examining the prevalence of different combined patterns and their correlations with depression, anxiety, and self-injurious behavior among Chinese adolescents.

Methods: Junior and senior high school students (N = 13,659; mean age 15.18±1.89) were recruited. Latent class analysis was conducted to identify combined patterns of MVPA and SSB. Associations between subgroups of MVPA and SSB and socio-demographic characteristics were assessed by logistic regression. Their correlation with depression, anxiety, and self-injurious behaviors was assessed by analysis of variance with analysis stratified by gender.

Results: Four latent classes were identified: high MVPA/low SSB group (64.7%), low MVPA/low SSB (26.7%), low MVPA/high SSB (4.8%), and low MVPA/moderate SSB (3.9%). Generally, the high MVPA/low SSB class was a relatively healthy group. The low MVPA/high SSB class was at risk of enduring depression, anxiety, and self-injurious behavior, with boys being more at risk than girls.

Conclusion: Four latent subgroups of MVPA and SSB were identified in Chinese adolescents. The findings highlight the potential role of concurrent MVPA and SSB, with gender-specific characteristics in the primary prevention of adolescent depression, anxiety, and self-injurious behaviors.

Keywords: exercise, internet, media use, subgroups, mental health, suicide

Background

Adolescence is a critical period for the development of mental patterns and the establishment of behavioral patterns. The behavioral patterns that adolescents establish, in conjunction with the lifestyle choices that they make, could affect their present and future physical and mental health.^{1,2} Therefore, unhealthy, risky behaviors, and psychological problems among juveniles become a public health concern.^{3,4} Excessive physical inactivity and screen-based sedentary behavior

(SSB) are considered as new “invisible” risk behaviors, which are related to adolescent psychological problems.^{3,5} However, among adolescents worldwide, research showed that these two behaviors are highly prevalent.^{6,7} According to the literature, 80.3% of 13–15 years old adolescents across the 105 countries performed less than one hour of exercise under the WHO-recommended amount of moderate-to-vigorous physical activity (MVPA), and about 65% of adolescents reported spending more than two hours on SSB.⁸ To reduce the burden of psychological problems, including self-injurious behaviors, it is important to understand the patterns of MVPA and SSB among adolescents and their correlations with psychological symptoms and self-injurious behaviors.

The mechanisms underlying the beneficial effects of PA and SSB on psychological health remain imprecise.⁹ There may be a number of interacting biological, psychological and social mechanisms at play. For biological mechanisms, PA’s blunting/optimizing effects on hormonal stress responsive systems may buffer against stress-related diseases, and its beneficial effects of enhancing growth factor expression and neural plasticity contribute to improved mood and cognition.¹⁰ For psychological mechanisms, PA may change people’s general self-perceptions of confidence and competence by improving their self-perceptual subdomains of sport competence, perceived strength, physical condition, and physical attractiveness,¹¹ which in turn induces positive emotion and low anxiety. Finally, for social mechanisms, PA in a supportive group-based environment provides people more opportunities for positive social interaction which is a primary source of enjoyment and valuable for mental health.^{12,13}

Although the specific mechanism of SB’s effects on psychological health is still unclear, consistent findings have shown that physiological and psychological mechanisms may play roles, including decreasing stimulation-induced plasticity in the primary motor cortex and cerebral blood flow and metabolism which underpin brain health, with negative consequences on cognition and mental health,^{14,15} as well as cognitive performance.¹⁶

The displacement hypothesis predicts that the time spent on media use, which is also defined as SSB, competes with the time participating in other activities, such as physical activity (PA) in youth.^{17,18} Does this mean that high SSB must be related to low PA or vice versa? Is there any possibility of other combined patterns of PA and SSB in adolescents? A handful of researchers explored this

problem; and their findings have been inconsistent. Based on an average intensity of PA (average counts/min/day), Evenson et al¹⁹ found four different classes of accelerometer-measured sedentary behaviors (SBs) (13.5%, 18.0%, 30.1%, and 38.5% of population) and PA (3.1%, 3.6%, 33.3%, and 59.9% of population) in American youths (6–17-year-old). The patterns identified from this latent class analysis (LCA) study provide a novel way to explore PA and SB. However, it should be noted that the accelerometer used in this study is limited in its ability to count some other activities like swimming. Also, SB and reading behaviors could not be differentiated. A cluster analyses study conducted in Germany identified eight clusters of PA and media use for boys and seven clusters for girls. There were three high media-use groups that combined with low PA (low PA/very high games, low PA/high TV or PC, low PA/very high TV or games or PC).²⁰ These results support the displacement hypothesis that high SSB occurs with low PA. However, very high PA was also found occurring with mediate amounts of SSB in this study. Moreover, a high PA/high SSB group was found in American adolescents.^{21,22} Due to the effects of cultural differences on PA and SSB,^{23–25} it is necessary to explore combined patterns of these two factors in a different culture. Although a handful of studies^{25–28} have comprehensively explored the association of PA and SSB with mental health, as far as we know, there is no previous study examining specific combined patterns of PA and SSB in Chinese adolescents.

Although we can identify different combined typologies of PA and SSB in populations using LCA or cluster analyses, it is more important to understand their correlations with physical and mental health. According to the self-efficacy theory, PA may produce antidepressant and anti-anxiety effects.^{29–31} Many studies have explored independent associations of PA with depression and anxiety,^{30,32} but no study explored combined patterns of PA and SSB in adolescents and their correlations with psychological problems. However, the concurrent patterns of PA and SSB and their correlations with obesity, sleep duration,²¹ and cardiometabolic rates³³ have been studied. Four latent classes of PA and SSB (high PA/high SSB; high PA/low SSB; low PA/high SSB; and low PA/low SSB) were found among male and female American adolescents.^{21,22} Moreover, these results revealed that obesity had a greater propensity to occur for both genders in the subgroups with either low PA or high SSB. For females, the low PA/high SSB subgroup showed greater

likelihood of obesity compared to those with either high PA or low SSB. Compared to the high PA/low SSB subgroup, the low PA/high SSB subgroup had lower odds of having sufficient sleep.²² The combined patterns of PA and cardiometabolism were also examined.³³ Compared to the subgroup with least MVPA/most SB, the subgroup with most MVPA/least SB had lower systolic blood pressure, lower glucose, and lower insulin. In the above studies, the patterns of PA and SB are different, and their correlations with physical health among adolescents from the United States of America and Germany are also inconsistent. Thus, other representative samples are required. Furthermore, concurrent associations of PA and SSB on psychological health should be further explored.

The aim of this study was to extend the current literature by identifying subgroups of individuals based on combined patterns of MVPA and SSB using the LCA method and based on a large, diverse sample of Chinese female and male adolescents. More specifically, we tried to reach the following purposes: (1) we attempted to explore the prevalence of different combined patterns of MVPA and SSB in Chinese adolescents; (2) we aimed to examine the impact of socio-demographic factor (age, biological gender, body mass index (BMI), subjective social and economic status (SES), only child, parents' education and marriage, and family income) differences on these potentially grouped adolescents; (3) we also attempted to examine combined patterns of MVPA and SSB and their correlations with psychological problems, such as depression, anxiety, and self-injurious behaviors; (4) finally, because the gender differences of PA and SSB are highly reproducible and one of the most consistent findings in the literature,^{34,35} we performed all of these tests and analyses stratified by biological gender.

Methods

Participants And Recruitment

Data for this study were extracted from the National Assessment, Early-Warning and Intervention Model research on Youth Risk Behavior (NAEWIM-YRB) under the National Science- and Technology Support Plan project. Junior and senior high school students ($N = 13,659$; mean age = 15.18 ± 1.89) were recruited in randomly selected schools ($n = 23$; 264 classes) from 10 cities in mainland China. The time interval was from March to September 2011. More detailed information on study procedures and the 10 involved sampling centers can be found

elsewhere.^{6,36} This research ethic was approved by the Human Subjects Review Committee at the Second Xiangya Hospital of Central South University (No: CSMC-2009S167). Students completed the paper-based questionnaires individually in a classroom supervised by a research assistant. All participants and their parents provided written informed consent.

Measurements

MVPA And SSB

A self-administered questionnaire was completed by adolescents in the participating schools. It covered socio-demographic information, including age, biological gender, and subjective social and economic status (SES). MVPA and SSB were assessed by the Youth Risk Behavior Survey questionnaire.³⁷ MVPA was assessed based on the students' MVPA in the past seven days. For example, how many days in the past 7 days (0–7 days) was the subject physically active enough to breathe harder or make her or his heart beat faster for more than 60 mins per day? In line with previous studies, responses were categorized into three groups: no MVPA group (0 d/wk), moderate MVPA frequency group (≥ 1 to ≤ 3 d/wk), and high MVPA frequency group (> 3 d/wk).⁶ Assessment of SSB was based on the daily average hours spent on watching television, playing video games, or using the computer on a typical school day. Also in line with the previous studies, SSB were categorized into four groups: no SSB group (0 h/d), low SSB group (≤ 1 h/d), moderate SSB group (> 1 to < 2 h/d), and high SSB group (≥ 2 h/d).³⁸ The internal consistency reliability (Cronbach's Alpha) of all scales or subscales was ranged from 0.71 to 0.95.

Depression, Anxiety, And Self-Injury

All measurement instruments for mental health were administered in a single session. Symptoms of depression were assessed using the 20-item Centers for Epidemiologic Studies Depression scale.^{39,40} Anxiety symptoms were measured using the 39-item Multidimensional Anxiety Scale for Children.^{41,42} Besides the total anxiety score, subscales measuring physical symptoms (tense/restless and somatic/autonomic), social anxiety (humiliation/rejection and public performance fears), harm avoidance perfectionism and anxious coping, and separation anxiety were also used for data analysis. The officially translated and validated Chinese versions of these instruments were used. Self-injurious behavior was measured using a 5-item

subscale extracted from the Health-Risk Behavior Inventory for Chinese Adolescents.⁴³ All of these measurements were used as continuous variables, and were confirmed to be internally consistent (Cronbach's alphas ranged from 0.64 to 0.95).

Statistical Analysis

F-tests of independence were conducted for continuous variables, and chi-square tests were conducted for categorical variables in order to statistically compare the differences between each MVPA/SSB group and different socio-demographic factors.

To identify clusters of adolescents with similar MVPA/SSB behavior profiles, the LCA was conducted without any a priori assumption of the nature of the latent categorization. F-tests of independence and chi-square tests were used to identify significant differences between each latent subgroup of MVPA/SSB identified by the LCA for socio-demographic factors, depression symptoms, and anxiety symptoms. All these tests and analyses were stratified by biological gender.

A *p* value less than 0.05 (two-tailed) was considered to be statistically significant for all analyses. All statistical analyses were performed using SPSS 19.0 and MPLUS 7.0 for Windows.

Results

The prevalence (%) of each group of MVPA and SSB is reported in additional files [Tables S1–S3](#).

Classes Identified Through LCA

LCA was applied to the MVPA and SSB in a subsample of 13,163 pupils with no missing information for any items. Parameters of fit and the proportion of individuals in each class are presented ([Table S4](#)). The entropy was the highest at four classes (0.822). The Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and sample-size adjusted Bayesian Information Criterion (aBIC) continued to decrease from one to four classes, with the exception of the BIC at four classes, which was slightly higher than three classes (75,381.713 vs 75,364.985). However, the aBIC decreased at four classes. Taking these indicators into consideration, a four latent subgroup model would best fit the data when compared to the other models. The latent classes of the four subgroups based on item probabilities are shown in [Figure 1](#).

Class 1 (high MVPA/low SSB) comprised 64.7% of the sample (M/F=3646/4303), which included pupils with

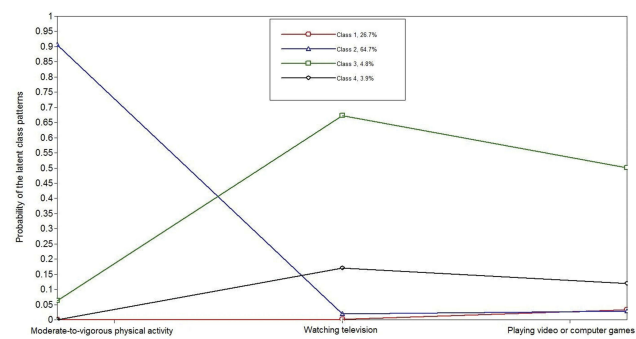


Figure 1 Profiles of the four MVPA/SSB classes. Proportions for the latent classes were based on estimated posterior probabilities. Class 1, low MVPA/low SSB group (26.7%); Class 2, high MVPA/low SSB group (64.7%); Class 3, low MVPA/high SSB group (4.8%); Class 4, low MVPA/moderate SSB group (3.9%); MVPA, moderate to vigorous physical activity; SSB, screen-related sedentary behavior; Red line: Class 1; blue line: Class 2; green line: Class 3; black line: Class 4.

high MVPA and low SSB behaviors. Class 2 (low MVPA/low SSB) comprised 26.7% of the sample (M/F=2359/1822), which included students who scored low on both MVPA and SSB behaviors. Class 3 (low MVPA/high SSB) comprised 4.8% of the sample (M/F=343/175), which included students who were high on television and games/computer usage time and low MVPA. Class 4 (low MVPA/moderate SSB) comprised 3.9% of the sample (M/F=276/195), which included pupils with low MVPA and moderate SSB.

Combined Patterns And Their Correlates

[Table 1](#) describes the association of the subgroups identified through LCA and socio-demographic variables. The mean age of pupils in class 1 ($M \pm SD$: 15.29 \pm 1.92) was significantly higher than that in the other classes ($p < 0.001$), and pupils in class 2 were older than those in class 4 ($p < 0.001$). BMI was only significantly higher in class 2 ($p = 0.001$) than in class 1. SES was significantly higher in class 1 and class 2 compared to class 3 and class 4 ($p < 0.001$).

Multinomial logistic regression analysis revealed significant differences in gender, grade, only child status, intactness of parents' marriage, level of paternal and maternal education, and family income between the high MVPA/low SSB group and the other three groups. After adjusting for age, there were significantly more females in the high MVPA/low SSB group than in the other groups (OR ranged from 0.43 to 0.65). Additionally, after adjusting for gender, the high MVPA/low SSB group had more senior students (OR ranged from 0.56 to 0.79) and more students from high-income families (OR ranged from 0.70

Table 1 Socio-Demographic Differences By Latent Class MVPA/SSB Behaviors Group

	Total (n = 13,163)	high MVPA/low SSB (n=7,983)	low MVPA/low SSB (n=4,189)	low MVPA/high SSB (n=518)	low MVPA/ moderate SSB (n=473)	p
Age, Mean (SD) (33 ^M)	15.20 (1.89)	15.29 (1.92)	15.10 (1.84)	14.99 (1.73)	14.70 (1.84)	<0.001 (a>b,c,d; b>d)
Female, OR (95% CI) (57 ^M)		1.00	0.65(0.61–0.70)	0.43(0.36–0.52)	0.60(0.49–0.72)	Adjusted age
BMI, Mean (SD) (1022 ^M)	19.62(3.34)	19.53(3.21)	19.74(3.48)	19.84(3.67)	19.73(3.80)	0.001 (a<b)
SES, Mean (SD) (789 ^M)	6.42(1.59)	6.46(1.60)	6.41(1.54)	6.13(1.65)	6.07(1.61)	<0.001 (a>c,d; b>c,d)
Senior grads respondents (10, 11, 12grade), OR (95% CI) (47 ^M)		1.00	0.79(0.73–0.85)	0.76(0.64–0.91)	0.56(0.46–0.68)	Adjusted gender
Only child, OR (95% CI) (867 ^M)		1.00	1.04(0.96–1.13)	0.99(0.81–1.21)	1.17(0.95–1.44)	Adjusted gender
Intactness of parents' marriage, OR (95% CI) (310 ^M)		1.00	0.91(0.79–1.05)	0.53(0.41–0.70)	0.49(0.38–0.65)	Adjusted gender
High level of paternal education, OR (95% CI) (2609 ^M)		1.00	1.10(1.01–1.19)	0.78(0.64–0.97)	0.85(0.69–1.05)	Adjusted gender
High level of Maternal education, OR (95% CI) (2686 ^M)		1.00	1.09(1.00–1.18)	0.76(0.61–0.94)	0.91(0.73–1.13)	Adjusted gender
High level of family income, OR (95% CI) (1575 ^M)		1.00	0.89(0.82–0.97)	0.75(0.61–0.91)	0.70(0.56–0.86)	Adjusted gender

Abbreviations: MVPA, moderate to vigorous physical activity; SSB, Screen-based sedentary behavior; BMI, body mass index; SES, socioeconomic status; SES, subjective economic status, was considered as continuous variables (ranging from 1-the worst, to 10-the best); a, Class1, high MVPA/low SSB; b, Class2, low MVPA/low SSB; c, Class3, low MVPA/high SSB; d, Class4, low MVPA/moderate SSB; M, missing data.

to 0.89) than in the other groups. For both high level of paternal and maternal education group, there were more pupils in class 1 than in class 3 (OR, 0.78; 95% CI: 0.64–0.97 for paternal education and OR, 0.76; 95% CI: 0.61–0.94 for maternal education), but fewer pupils than those in class 2 (OR, 1.10; 95% CI: 1.01–1.19 for paternal education and OR, 1.09; 95% CI: 1.00–1.18 for maternal education), after adjusting gender. Moreover, parental marriage was reported to be more intact for pupils in class 1 compared to those in class 3 (OR, 0.53; 95% CI: 0.41–0.70) and class 4 (OR, 0.49; 95% CI: 0.38–0.65) after adjusting for gender.

Analysis of variances for depressive and anxiety symptoms and self-injurious behaviors among the four subgroups stratified by biological gender are reported in Tables 2 and 3. For boys, levels of depressive symptoms were

significantly higher in class 3 compared to those in class 1 ($p<0.001$) and in class 2 ($p<0.001$). A similar pattern was observed for total anxiety ($p=0.014$; $p=0.009$), physical symptoms of anxiety ($p<0.001$; $p<0.001$), separation anxiety ($p<0.001$; $p=0.001$), and finally suicide and self-injurious behaviors ($p<0.001$; $p<0.001$). However, pupils in class 4 showed higher separation anxiety than those in class 1 ($p=0.021$), and they also showed higher self-injurious behaviors than those in class 2 ($p=0.012$). For girls, depressive symptoms were significantly lower in class 1 compared to those in class 3 ($p<0.001$) and those in class 2 ($p=0.016$). Furthermore, depressive symptoms in class 3 were also significantly higher than those in class 2 ($p=0.005$). For girls as well as boys, self-injurious behavior was more severe in class 3 than those in class 1 ($p<0.001$) and those in class 2 ($p<0.001$), but no significant

Table 2 Differences In Psychological Problems (M±SD) By Latent Classes Of MVPA/SSB In Boys

	Total (N=6,624)	high MVPA/low SSB (n=3,646)	low MVPA/low SSB (n=2,359)	low MVPA/high SSB (n=343)	low MVPA/ moderate SSB (n=276)	P
Depression	16.71(9.09)	16.64 (9.17)	16.40(8.77)	19.18(9.95)	17.37(9.22)	<0.001(1,2<3)
Anxiety (total)	33.18(20.09)	32.9 8(20.10)	32.75(19.53)	36.61(22.91)	35.27(20.69)	0.004(1,2<3)
Physical symptoms	7.80(6.78)	7.70(6.75)	7.60(6.56)	9.52(7.86)	8.71(7.24)	<0.001(1,2<3)
Social anxiety	9.22(6.35)	9.25(6.42)	9.06(6.22)	9.72(6.58)	9.58(6.20)	0.260
Harm avoidance	10.13(5.23)	10.15(5.23)	10.10(5.14)	10.03(5.94)	10.16(5.12)	0.973
Separation anxiety	6.08(4.69)	5.96(4.66)	6.04(4.57)	7.14(5.46)	6.86(5.02)	<0.001(1,2<3; 1<4)
Self-injurious behavior	6.10(2.24)	6.08(2.23)	6.00(2.10)	6.62(2.90)	6.45(2.41)	<0.001(1,2<3; 2<4)

Abbreviations: MVPA, moderate to vigorous physical activity; SSB, Screen-based sedentary behavior.

Table 3 Differences In Psychological Problems (M±SD) By Latent Classes Of MVPA/SSB In Girls

	Total (N=6,495)	high MVPA/low SSB (n=4303)	low MVPA/low SSB (n=1822)	low MVPA/high SSB (n=175)	low MVPA/ moderate SSB (n=195)	p
Depression	17.78(9.31)	17.43(9.29)	18.22(9.20)	20.69(9.91)	18.66(9.41)	<0.001(1<2,3; 2<3)
Anxiety total	40.54(19.57)	40.24(19.55)	41.21(19.17)	42.50(22.52)	39.23(20.75)	0.130
Physical symptoms	9.53(6.86)	9.34(6.75)	9.87(6.93)	10.74(8.09)	9.56(7.38)	0.006(1<2)
Social anxiety	11.18(6.21)	11.12(6.27)	11.30(6.04)	11.95(6.42)	10.73(6.39)	0.217
Harm avoidance	11.77(4.88)	11.80(4.90)	11.80(4.78)	11.75(5.62)	10.89(4.69)	0.095
Separation anxiety	8.31(4.91)	8.23(4.89)	8.48(4.87)	8.58(5.47)	8.15(5.19)	0.297
Self-injurious behavior	6.44(2.63)	6.36(2.54)	6.52(2.73)	7.41(3.22)	6.61(2.76)	<0.001(1,2<3)

Abbreviations: MVPA, moderate to vigorous physical activity; SSB, Screen-based sedentary behavior.

differences were found between class 4 and other groups. Finally, girls in class 2 reported significantly higher scores on physical symptoms than those in class 1 ($p=0.042$).

Discussion

This research is a large, nationally representative study that explored the combined patterns of MVPA and SSB in Chinese adolescents. To our knowledge, it is also the first study that considers the effects of MVPA and SSB together with depression, anxiety, and self-injurious behavior. Results from the LCA indicated that Chinese adolescents can be grouped into four clusters: high MVPA/low SSB class, low MVPA/low SSB class, low MVPA/high SSB class, and low MVPA/moderate SSB class. Additionally, there are differences among these four subgroups regarding socio-demographic factors, depression, anxiety and self-injurious behaviors. Ultimately, the implications of these results provide researchers and clinicians a better understanding of the relational pattern of these behaviors for adolescents.

Generally, it is considered that either high PA or low SB is healthy for adolescents.^{32,38,44,45} This study's findings supported this idea. Specifically, the high MVPA/low SSB class, who met both the WHO-recommended amount of MVPA and SSB, was considered as a relatively healthy group, because they showed lower symptom levels in most psychological problems than in the other classes. This finding is also in line with results obtained from a recent research conducted in the United States.²² Kim and colleagues identified four latent subgroups with multiple combined levels of MVPA and SSB, which were stratified by gender (high MVPA/low SSB class, high MVPA/high SSB class, low MVPA/high SSB class, and low MVPA/low SSB class). Likewise, in line with the results on obesity and sleep duration, the low MVPA/high SSB subgroup, who failed to reach WHO recommendations, was considered to be at risk of enduring depression, anxiety and self-injurious behavior. This study's results support the self-efficacy theory in which PA may produce antidepressant and anti-anxiety effects.²⁹⁻³¹

Furthermore, our findings seem to support the displacement hypothesis: excessive media consumption displaces other protective experiences, such as active/productive activities and sleep, while lack of protective experiences would hinder normal cognitive and emotional development.⁴⁶⁻⁴⁸ Meanwhile, the intactness of parental marriage and family income of adolescents in the high MVPA/low SSB group were reported to be better than that in the other groups. Parental marriage intactness and family income have been shown to be beneficial to adolescents' mental health.⁴⁹⁻⁵¹ Therefore, it is not surprising that adolescents in the high MVPA/low SSB group showed better health performance (depression and anxiety) than those in the other groups.

Interestingly, the groups found in this study differed from those found in the US. Specifically, no high PA/high SSB group (20.3% for male and 17.6% for female US adolescents) was found in Chinese adolescents. Instead, a low MVPA/moderate SSB group (3.9% for Chinese adolescents) was found. For girls, there was no significant difference between the low MVPA/moderate SSB and other three LCA groups on depression, anxiety, and self-injurious behaviors. Generally, the third class, which was low MVPA/high SSB, was a definite high risk group for boys' mental health (5 out of 7 indicators), but not really for girls (2 out of 7 indicators). Additionally, compared with boys in the high MVPA/low SSB group, boys in the low MVPA/moderate SSB group showed significantly higher symptoms of separation anxiety, and compared with boys in the low MVPA/low SSB group, they showed higher self-injurious behavior; no high risk of this group was found for girls. These results are consistent with a previous study in which high overall media exposure (including television, videocassettes, video games and radio) was associated with a lower risk of depression in young women,⁴⁸ which indicates that SSB, including television, video games, and some other computer use, may have a more negative influence on boys than girls. Further studies comparing the two genders are needed to clarify this issue.

In this study, a subgroup (moderate SSB group) was found, and its psychological characteristics partly supported previous studies, which suggested that appropriate SSB,³⁸ such as internet usage for non-educational purposes, is associated with lower risk of depression compared to the no-SSB group. This finding is in contrast to common guidelines and WHO recommendations,^{52,53} both of which emphasize the positive association between SSB

and health risks. A possible reason may be that SSB could enhance a teenager's reading ability, and in turn, improve his or her reading ability and promote academic performance. Adolescents' reading ability may also benefit from processing humorous content on the screen.⁴⁸

However, this is a subgroup of moderate SSB with low MVPA, and low PA was found to be associated with high psychological problems, including depression and anxiety.^{32,54} Therefore, low MVPA behaviors may neutralize the advantages of the moderate SSB, especially for boys. Boys in this group had significantly higher symptoms of separation anxiety compared with those in the high MVPA/low SSB group. This gender difference is inconsistent with the results found in a previous study in which boys with more media use in United States had lower levels of anxiety than those in the normative group.⁵⁵ Different measures of media use may cause these contradictory results. In the Ohannessian's study, the media-use questionnaire included several other items, such as the time spent talking on the phone, texting, and emailing, which were not included in the present study. Besides, Ohannessian's study did not concern the influence of PA, so it is not suitable to directly compare their results with this study. More concurrent associations of MVPA and SSB with psychological problems are needed to clarify the issue.

Strengths And Limitations

In recent times, the decrease of PA during childhood and adolescent years is found worldwide, especially for girls,⁵⁶ and this phenomenon is accompanied by the increase of SB, especially in association with screen exposure.⁵⁷ Greater efforts to disseminate information about the effects of different lifestyle patterns of PA and SB in relation to physical or psychological health is needed to prevent negative health outcomes of inadequate PA and SB. Although the implications of this study's findings are fruitful, this study still has some limitations. Firstly, given the fact that this is an observational study, there may be potential biases that are brought about by other lifestyle factors. Therefore, it is not possible to determine temporal associations. Therefore, causality cannot be inferred. Experimental data or longitudinal data are needed to further explore the combined patterns of MVPA and SSB and their correlations. Secondly, there was no measurement of SSB exposure during weekend days. Hence, researchers should be more cautious when interpreting results in the current study. Further subtypes of detailed and complete MVPA and SSB, as well as their correlations with other factors should be taken into consideration, such as cognitive ability and happiness.

Furthermore, self-reported MVPA and SSB data may not provide accurate estimates, further research would benefit from using different measuring methods, such as using accelerometry and interviews. Finally, due to the multistage cluster sampling method, the findings of this study may not apply to adolescents who are homeschooled or truant from school. Future studies may incorporate data for these off-school students.

Conclusion

Chinese adolescents' MVPA and SSB lifestyle patterns can be divided into four distinct subgroups: high MVPA/low SSB, low MVPA/low SSB, low MVPA/high SSB, and low MVPA/moderate SSB. For Chinese adolescents, these four groups showed significantly different likelihoods of depression, anxiety and self-injurious behaviors, with boys being more at risk than girls. Importantly, the high MVPA/low SSB subgroup, who met both WHO's recommendations for PA and screen time, had significantly lower depression, anxiety and self-injurious behaviors compared to the other groups. On the contrary, the low MVPA/high SSB subgroups, who failed to reach WHO's recommendations for PA and screen time, had significantly higher depression, anxiety and self-injurious behaviors. The results of the current study highlight the potential role of the interplay between MVPA and SSB, in the prevention of adolescent depression, anxiety and self-injurious behaviors among both genders.

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Disclosure

The authors report no conflicts of interest in this work.

References

- Bird HR, Davies M, Duarte CS, et al. A study of disruptive behavior disorders in Puerto Rican Youth. *J Am Acad Child Adolesc Psychiatry.* 2006;45(9):1042–1053. doi:10.1097/01.chi.0000227879.65651.cf
- Jiang N, Kolbe LJ, Seo DC, Kay NS, Brindis CD. Health of adolescents and young adults: trends in achieving the 21 critical national health objectives by 2010. *J Adolesc Health.* 2011;49(2):124–132. doi:10.1016/j.jadohealth.2011.04.026
- Carli V, Hoven CW, Wasserman C, et al. A newly identified group of adolescents at “invisible” risk for psychopathology and suicidal behavior: findings from the SEYLE study. *World Psychiatry.* 2014;13(1):78–86. doi:10.1002/wps.v13.1
- Patton GC, Coffey C, Cappa C, et al. Health of the world's adolescents: a synthesis of internationally comparable data. *Lancet.* 2012;379(9826):1665–1675. doi:10.1016/S0140-6736(12)60203-7
- Straatmann VS, Oliveira AJ, Rostila M, Lopes CS. Changes in physical activity and screen time related to psychological well-being in early adolescence: findings from longitudinal study ELANA. *BMC Public Health.* 2016;16(1):977. doi:10.1186/s12889-016-3606-8
- Liu M, Ming Q, Yi J, Wang X, Yao S. Screen time on school days and risks for psychiatric symptoms and self-harm in Mainland Chinese adolescents. *Front Psychol.* 2016;7(502). doi:10.3389/fpsyg.2016.00574
- McMahon EM, Corcoran P, Grace OR, et al. Physical activity in european adolescents and associations with anxiety, depression and well-being. *Eur Child Adolesc Psychiatry.* 2017;26(1):111–122. doi:10.1007/s00787-016-0875-9
- Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet.* 2012;380(9838):247–257. doi:10.1016/S0140-6736(12)60646-1
- Biddle SJ, Ciaccioni S, Thomas G, Vergeer I. Physical activity and mental health in children and adolescents: an updated review of reviews and an analysis of causality. *Psychol Sport Exerc.* 2019;42:146–155.
- Silverman MN, Deuster PA. Biological mechanisms underlying the role of physical fitness in health and resilience. *Interface Focus.* 2014;4(5):20140040. doi:10.1098/rsfs.2014.0040
- Fox KR, Corbin CB. The physical self-perception profile: development and preliminary validation. *J Sport Exerc Psychol.* 1989;11(4):408–430. doi:10.1123/jsep.11.4.408
- Fox KR, Stathi A, McKenna J, Davis MG. Physical activity and mental well-being in older people participating in the Better Ageing Project. *Eur J Appl Physiol.* 2007;100(5):591–602. doi:10.1007/s00421-007-0392-0
- Mutrie N, Faulkner G. Physical activity: positive psychology in motion. *Positive Psychol Pract.* 2004;146–164.
- Singh AM, Neva JL, Staines WR. Acute exercise enhances the response to paired associative stimulation-induced plasticity in the primary motor cortex. *Exp Brain Res.* 2014;232(11):3675–3685. doi:10.1007/s00221-014-4049-z
- Smith KJ, Ainslie PN. Regulation of cerebral blood flow and metabolism during exercise. *Exp Physiol.* 2017;102(11):1356–1371. doi:10.1113/EP086249
- Falek RS, Davis JC, Liu-Ambrose T. What is the association between sedentary behaviour and cognitive function? A systematic review. *Br J Sports Med.* 2017;51(10):800–811. doi:10.1136/bjsports-2015-095551
- Marshall SJ, Biddle SJ, Gorely T, Cameron N, Murdey I. Relationships between media use, body fatness and physical activity in children and youth: a meta-analysis. *Int J Obes Relat Metab Disord.* 2004;28(10):1238.

18. Mutz DC, Roberts DF, Vuuren DPV. Reconsidering the displacement hypothesis. *Communic Res.* 1993;20(1):51–75. doi:10.1177/009365093020001003
19. Evenson KR, Wen F, Hales D, Herring AH. National youth sedentary behavior and physical activity daily patterns using latent class analysis applied to accelerometry. *Int J Behav Nutr Phys Act.* 2016;13. doi:10.1186/s12966-016-0382-x
20. Spengler S, Mess F, Woll A. Do media use and physical activity compete in adolescents? Results of the MoMo Study. *PLoS One.* 2015;10(12):e0142544. doi:10.1371/journal.pone.0142544
21. Kim Y, Barreira TV, Kang M. Concurrent associations of physical activity and screen-based sedentary behavior on obesity among US adolescents: a latent class analysis. *J Epidemiol.* 2015;26(3):137–144. doi:10.2188/jea.JE20150068
22. Kim Y, Umeda M, Lochbaum M, Stegemeier S. Physical activity, screen-based sedentary behavior, and sleep duration in adolescents: youth risk behavior survey, 2011–2013. *Prev Chronic Dis.* 2016;13(9). doi:10.5888/pcd13.160245
23. Bauman AE, Reis RS, Sallis JF, et al. Correlates of physical activity: why are some people physically active and others not? *Lancet.* 2012;380(9838):258–271. doi:10.1016/S0140-6736(12)60735-1
24. Duch H, Fisher EM, Ensari I, Harrington A. Screen time use in children under 3 years old: a systematic review of correlates. *Int J Behav Nutr Phys Act.* 2013;10(1):102. doi:10.1186/1479-5868-10-102
25. Trost SG, Owen N, Bauman AE, Sallis JF, Brown W. Correlates of adults' participation in physical activity: review and update. *Med Sci Sports Exerc.* 2002;34(12):1996. doi:10.1097/00005768-200212000-00020
26. Hrafnkelsdottir SM, Brychta RJ, Rognvaldsdottir V, et al. Less screen time and more frequent vigorous physical activity is associated with lower risk of reporting negative mental health symptoms among Icelandic adolescents. *PLoS One.* 2018;13(4):e0196286. doi:10.1371/journal.pone.0196286
27. Wu X, Tao S, Zhang Y, Zhang S, Tao F. Low physical activity and high screen time can increase the risks of mental health problems and poor sleep quality among Chinese college students. *PLoS One.* 2015;10(3):e0119607. doi:10.1371/journal.pone.0119607
28. Feng Q, Du Y, Ye Y-L, He -Q-Q. Associations of physical activity, screen time with depression, anxiety and sleep quality among Chinese college freshmen. *PLoS One.* 2014;9(6):e100914. doi:10.1371/journal.pone.0100914
29. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. *Psychol Rev.* 1977;84(2):191–215. doi:10.1037/0033-295X.84.2.191
30. Bruner A, Gudmundsdottir SL, Augestad LB. Gender-specific associations between leisure-time physical activity and symptoms of anxiety: the HUNT study. *Soc Psychiatry Psychiatr Epidemiol.* 2015;50(3):419–427. doi:10.1007/s00127-014-0915-z
31. Salmon P. Effects of physical exercise on anxiety, depression, and sensitivity to stress: a unifying theory. *Clin Psychol Rev.* 2001;21(1):33–61. doi:10.1016/S0272-7358(99)00032-X
32. Brown HE, Pearson N, Braithwaite RE, Brown WJ, Biddle SJH. Physical activity interventions and depression in children and adolescents. *Sports Med.* 2013;43(3):195–206. doi:10.1007/s40279-012-0015-8
33. Jenkins GP, Evenson KR, Herring AH, Hales D, Stevens J. Cardiometabolic correlates of physical activity and sedentary patterns in US youth. *Med Sci Sports Exerc.* 2017;49(9):1826–1833. doi:10.1249/MSS.0000000000001310
34. Biddle SJ, Mutrie N. *Psychology of Physical Activity: Determinants, Well-Being and Interventions.* Routledge; 2007.
35. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc.* 2000;32(5):963–975. doi:10.1097/00005768-200005000-00014
36. Xin X, Ming Q, Zhang J, et al. Four Distinct Subgroups of self-injurious behavior among Chinese adolescents: findings from a latent class analysis. *PLoS One.* 2016;11(7):e0158609. doi:10.1371/journal.pone.0158609
37. Brener ND, Collins JL, Kann L, Warren CW, Williams BI. Reliability of the youth risk behavior survey questionnaire. *J Adolesc Health.* 2002;31(4):336–342. doi:10.1016/S1054-139X(02)00339-7
38. Liu M, Wu L, Yao S. Dose–response association of screen time-based sedentary behaviour in children and adolescents and depression: a meta-analysis of observational studies. *Br J Sports Med.* 2016;50(20):1252–1258. doi:10.1136/bjsports-2015-095084
39. Radloff LS. The CES-D scale a self-report depression scale for research in the general population. *Appl Psychol Meas.* 1977;1(3):385–401. doi:10.1177/014662167700100306
40. Wang M, Armour C, Wu Y, et al. Factor structure of the ces-d and measurement invariance across gender in mainland chinese adolescents. *J Clin Psychol.* 2013;69(9):966–979. doi:10.1002/jclp.2013.69.issue-9
41. March JS, Parker JDA, Sullivan K, Stallings P, Conners CK. The multidimensional anxiety scale for children (masc): factor structure, reliability, and validity. *J Am Acad Child Adolesc Psychiatry.* 1997;36(4):554–565. doi:10.1097/00004583-199704000-00019
42. Yao S, Zou T, Zhu X, et al. Reliability and validity of the chinese version of the multidimensional anxiety scale for children among chinese secondary school students. *Child Psychiatry Hum Dev.* 2007;38(1):1–16. doi:10.1007/s10578-006-0039-0
43. Wang M, Yi J, Cai L, et al. Development and psychometric properties of the health-risk behavior inventory for Chinese adolescents. *BMC Med Res Methodol.* 2012;12:94. doi:10.1186/1471-2288-12-94
44. Liu M, Wu L, Ming Q. How does physical activity intervention improve self-esteem and self-concept in children and adolescents? Evidence from a meta-analysis. *PLoS One.* 2015;10(8):e0134804. doi:10.1371/journal.pone.0134804
45. Penedo FJ, Dahn JR. Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Curr Opin Psychiatry.* 2005;18(2):189–193. doi:10.1097/00001504-200503000-00013
46. Eggermont S, Van den Bulck J. Nodding off or switching off? The use of popular media as a sleep aid in secondary-school children. *J Paediatr Child Health.* 2006;42(7–8):428–433. doi:10.1111/jpc.2006.42.issue-7-8
47. Kraut R, Patterson M, Lundmark V, et al. Internet paradox. A social technology that reduces social involvement and psychological well-being? *Am Psychol.* 1998;53(9):1017–1031. doi:10.1037/0003-066X.53.9.1017
48. Primack BA, Swanier B, Georgiopoulos AM, Land SR, Fine MJ. Association between media use in adolescence and depression in young adulthood: a longitudinal study. *Arch Gen Psychiatry.* 2009;66(2):181. doi:10.1001/archgenpsychiatry.2008.532
49. Amato PR, Sobolewski JM. The effects of divorce and marital discord on adult children's psychological well-being. *Am Sociol Rev.* 2001;66(6):900–921. doi:10.2307/3088878
50. Koball HL, Moiduddin E, Henderson J, Goesling B, Besculides M. What do we know about the link between marriage and health? *J Fam Issues.* 2010;31(8):1019–1040. doi:10.1177/0192513X10365834
51. Sturm R, Gresenz CR. Relations of income inequality and family income to chronic medical conditions and mental health disorders: national survey in USA. *BMJ.* 2002;324(7328):20–23. doi:10.1136/bmj.324.7328.20
52. Education AAoPCoP. American academy of pediatrics: children, adolescents, and television. *Pediatrics.* 2001;107(2):423–426. doi:10.1542/peds.107.2.423

53. Tremblay MS, Leblanc AG, Janssen I, et al. Canadian sedentary behaviour guidelines for children and youth. *Appl Physiol Nutr Metab*. 2011;36(1):59–64. doi:10.1139/H11-012
54. Hassmén P, Koivula N, Uutela A. Physical exercise and psychological well-being: a population study in Finland. *Prev Med*. 2000;30(1):17–25. doi:10.1006/pmed.1999.0597
55. Ohannessian CM. Media use and adolescent psychological adjustment: an examination of gender differences. *J Child Fam Stud*. 2009;18(5):582–593. doi:10.1007/s10826-009-9261-2
56. Dumith SC, Gigante DP, Domingues MR, et al. Predictors of physical activity change during adolescence: a 3.5-year follow-up. *Public Health Nutr*. 2012;15(12):2237–2245. doi:10.1017/S1368980012000948
57. Taveras EM, Field AE, Berkey CS, et al. Longitudinal relationship between television viewing and leisure-time physical activity during adolescence. *Pediatrics*. 2007;119(2):e314. doi:10.1542/peds.2005-2974

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