The Canadian 24-hour movement guidelines and psychological distress among adolescents

Running Head: 24-hour movement guidelines, anxiety, and depression

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ABSTRACT

Objective: The Canadian 24-Hour Movement Guidelines for Children and Youth recommend at least 60 minutes of physical activity per day, 2 hours or less of recreational screen time per day, and 9-11 hours of sleep per night for 5-13 years old and 8-10 hours per night for 14-17 years old. This study examined the association between meeting these guidelines and psychological distress among adolescents.

Methods: The present cross-sectional sample included 6,364 students aged 11 to 20 years from the 2017 Ontario Student Drug Use and Health Survey. This provincially representative school-based survey is based on a 2-stage cluster design. A confirmatory factor analysis was first conducted to confirm the factor structure of the K6, and structural equation modelling adjusted for age, sex, ethnoracial background, subjective socioeconomic status, and body mass index z-score was used to investigate the association between meeting the 24-Hour Movement Guidelines and K6 factors among adolescents.

Results: The confirmatory factor analysis demonstrated that a two-factor model (representing anxiety and depressive symptoms) of the K6 fit the data well. The anxiety and depression items demonstrated a composite reliability (Cronbach's alpha) of 0.86 and 0.83, respectively, indicating a high level of internal consistency. Compared to meeting none of the recommendations, meeting all 3 movement behaviour recommendations was associated with lower anxiety ($\beta = -0.076$; p=0.028) and depressive symptoms ($\beta = -0.067$; p=0.028). Meeting the screen time + sleep duration recommendations had the strongest association with anxiety ($\beta = -0.157$; p<0.001) and depressive symptoms ($\beta = -0.139$; p<0.001), followed by meeting the sleep duration recommendation only for both anxiety ($\beta = -0.135$; p<0.001) and depressive symptoms ($\beta = -0.106$; p<0.001).

Conclusions: Meeting the 24-hour movement guidelines was associated with lower anxiety and depressive symptoms among adolescents, and these associations appear mainly driven by meeting the sleep duration recommendation.

Key words: physical activity; sedentary behaviour; sleep; anxiety; depression**;** adolescents; epidemiology

INTRODUCTION

Adolescent mental health problems are common, disabling, and have long-term consequences for individuals, families, and communities.[1,2] Psychological distress is often defined as a state of emotional suffering characterized by symptoms of depression and anxiety.[3] It is a risk indicator for common major psychiatric disorders such as depression and anxiety disorders.[4] Distress is common among adolescents; for example, the proportion of adolescents with moderate to high level of psychological distress was 24% in 2013 and increased to 39% in 2017.[5] There is a need to identify correlates of anxiety and depressive symptoms that are amenable to intervention strategies in this population.

The way school-aged children and adolescents spend their time over a 24-hour period has important mental health implications.[3] Unhealthy lifestyle behaviours, such as lack of physical activity, excessive sedentary behaviour, and short sleep duration have been individually shown to be important determinants of anxiety and depressive symptoms among children and adolescents.[6-10] However, little is known on how these behaviours may concurrently relate to mental health problems among adolescents. Indeed, the importance of an integrated approach that considers all behaviours across the movement continuum has been previously highlighted.[11-13] The *Canadian 24-Hour Movement Guidelines for Children and Youth* were released in June 2016. These Guidelines provide specific recommendations on the amount of time during a typical 24-hour day that children and youth aged 5 to 17 should spend in moderate-to-vigorous physical activity (at least 60 minutes), recreational screen time (no more than 2 hours), and sleep (9 to 11 hours for 5- to 13-year-olds; 8 to 10 hours for 14- to 17-year-olds).[12] Because physical activity, sedentary behaviour, and sleep duration are modifiable risk factors, there is great desire to optimize the healthy active living behaviours of children and adolescents to improve their mental health. However, it is unknown whether meeting all or some

combinations of the movement behaviour recommendations is more important to the mental health of children than meeting single behaviours. This information is important to inform future interventions and public health strategies aimed at promoting adolescent mental health.

The K6 scale is commonly used as a brief continuous scale of psychological distress.[14-16] However, the two-factor structure measuring anxiety and depressive symptoms, which represent the two most common forms of psychological distress,[17,18] has not been well established at the population level of adolescents. Although anxiety and depressive symptoms are highly correlated,[19,20] establishing if these represent different constructs in our data would provide important information to guide intervention. It is also unclear if movement behaviours may be differentially associated with symptoms of depression versus anxiety.

The purpose of this study was to examine the associations between meeting the recommendations from the 24-hour movement guidelines and psychological distress in a large and representative sample of adolescents.[15] We hypothesized that adolescents who meet the recommendations of the 24-hour movement guidelines would have lower scores of psychological distress than those who meet some or none of the recommendations. In order to achieve our main objective, we sought to confirm the factor structure of the Kessler 6-item psychological distress scale (K6), information that would also be important to inform intervention strategies of youth struggling with emotional distress.

METHODS

The Ontario Student Drug Use and Health Survey (OSDUHS) is a population survey of Ontario students in grades 7 through 12 in publicly funded schools.[21] Out of scope groups are adolescents who dropped out of school, the homeless and institutionalized youths. Conducted

biennially since in 1977, OSDUHS is the longest ongoing school survey in Canada and one of the longest in the world. The purpose of the OSDUHS is to identify epidemiological trends in student drug use, mental health, physical health, gambling, bullying, and other risk behaviours, as well as to identify risk and protective factors. The survey employs a stratified (region and school type), two-stage (school, class) cluster sample design. Within each stratum, schools are selected with probability-proportional-to-size, and within selected schools, classes are selected with equal probability.

The 2017 OSDUHS was approved by the Research Ethics Boards at the Centre for Addiction and Mental Health and York University, as well as 31 school board research review committees. Student participation required the consent/permission of several entities, including school boards, school principals, classroom teachers, parents for students aged under 18, and students themselves. The survey was self-administered, anonymous, and took approximately 30 minutes to complete. Four split ballot versions of the questionnaire were employed. This allowed researchers to include as many topics as possible in the survey, while minimizing the burden on students and schools to a fixed class period. As such, in each classroom, Form A and Form B were distributed alternatively (i.e. A, B, A, B) to achieve two near-equal random samples completing each form. In total, 11,435 students, from 764 classes, 353 schools, and 52 school boards participated in the survey. Participation rates were 61% for students, 94% for classes, and 61% for schools. The response rates were above average for a survey of students requiring active parental consent.[22] Reasons for nonresponse among students included absenteeism (12%) and unreturned consent forms or parental refusal (27%). Analyses for the present study are restricted to the random half sample of students ($N = 6,364$) who completed form A, which contained questions regarding psychological distress. Detailed information on the survey design and methods is available elsewhere.[21]

Dependent variable

The Kessler 6-item (K6) psychological distress scale assesses symptoms of depression and anxiety occurring over the most recent 4-week period.[4,23] Responses were scored on a five-point ordinal scale reflecting how often of over the past month respondents had experienced 6 symptoms, such as "feeling tired out for no good reason" and "sad or depressed". The measure has five response categories ranging from 0 (none of the time) to 4 (all of the time). It has been widely used in research with adolescents.[15,24-26] The psychometric properties of the K6 have been extensively examined among adolescents and young adults.[14-16,27] Some investigators have confirmed a single factor using confirmatory factor analysis (CFA),[14-16] while others found that a two-factor model (representing anxiety and depression) fit the data best.[27] There is thus some uncertainty as to the true factor structure of the measure.

Independent variables

Physical activity was measured using the following item: "On how many of the last 7 days were you physically active for a total of at least 60 minutes each day? Please add up all the time you spent in any kind of physical activity that increased your heart rate and made you breathe hard some of the time (some examples are brisk walking, running, rollerblading, biking, dancing, skateboarding, swimming, soccer, basketball, football). Please include both school and non-school activities." Response options ranged from 0 to 7 days. Screen time was measured using the following item: "In the last 7 days, about how many hours a day, on average, did you spend: watching TV/movies/videos, playing video games, texting, messaging, posting, or surfing the Internet in your free time? (Include time on any screen, such as a smartphone, tablet, TV, gaming device, computer, or wearable technology). Response options included none, less than 1 hour a day to 7 or more hours a day. Sleep duration was measured using the following item: "On an average school night, how many hours of sleep do you get?" Response options ranged

from 4 hours or less to 11 or more hours. Students who reported being physically active 7 days per week, accumulating 2 hours or less of daily recreational screen time, and sleeping 9–11 hours per night for 11–13-year-olds; 8–10 hours per night for 14–17-year-olds, or 7–9 hours per night for those ≥18 years of age were classified as meeting the recommendations of the 24-hour movement behaviour guidelines.[12] Single-item measures of physical activity and sleep have been demonstrated to provide reliable and valid assessments of physical activity and sleep among children and adolescents.[28,29] Self-report measures of sedentary behaviour have also been shown to have acceptable reliability and validity in children and adolescents.[30,31] Although the 24-hour movement guidelines we are referring to in this study are relevant for children and adolescents aged 5 to 17 years, we have included in our analyses students aged 18 to 20 years (n=269) because they are still in high school and may still have most features of adolescent life. Regardless, we run a sensitivity analysis excluding students aged 18 to 20 years. Different combinations of movement behaviours examined in the current study include meeting none or any of the following recommendations: (1) physical activity only, (2) screen time only, (3) sleep duration only, (4) physical activity + screen time, (5) physical activity + sleep duration, (6) screen time + sleep duration, and (7) physical activity + screen time + sleep duration.

Covariates

Covariates included age (years), sex (male/female), ethnoracial background (White/Black/East and South-East Asian/South Asian/Other), subjective socioeconomic status (SES), and body mass index (BMI) z-score. Subjective SES was measured using a modified version of the MacArthur Scale of Subjective Social Status.[32] BMI was calculated from self-reported measures of height and weight, and age- and sex-specific BMI z-scores were calculated using reference data from the World Health Organization.[33]

Statistical analyses

Analyses were conducted in Mplus 8.2 and were weighted and accounted for the complex sample design of the survey using TYPE=COMPLEX function. Descriptive characteristics of participants are presented using mean, standard deviation, counts, and proportions. Confirmatory factor analyses employing a weighted least squares means and variance-adjusted estimator were first carried out to examine the factorial structure of the Kessler 6 scale. Items were treated as continuous variables.[4,23] We explored three competing models based on previous work,[27] to determine which model was a better fit to the data and to be used in subsequent analyses. Specifically, Model 1 had all six items loading on a single factor representing psychological distress; Model 2 had the items loading on two correlated first-order factors representing depression and anxiety; and Model 3 had the items loading on two second-order factors representing depression and anxiety and having a second-order structure representing psychological distress. Composite reliability estimates of latent variables were tested using Raykov composite reliability.[34] Lastly, structural equation modelling was used to examine both the measurement model and the hypothesized structural model. In the hypothesized structural model, anxiety and depression were modeled as latent variables, and movement behaviour combinations modeled as observed variables. Covariates included age, sex, ethnoracial background, subjective SES, and BMI z-scores. Maximum likelihood estimation with robust standard errors was used to account for possible nonnormality in responses. Missing data were completely missing at random and were handled through full information maximum likelihood (FIML). Goodness of fit for the measurement models was determined using the root-mean-square error of approximation (RMSEA), comparative fit index (CFI), Tucker-Lewis Index (TLI), and standardized root square mean residual (SRMR). Model fit was considered acceptable if RMSEA and SRMR are below 0.08 and a good fit if they are less than 0.06, CFI and TLI values of 0.90 or above are seen as acceptable and 0.95 or above are

considered a good fit, and AIC and BIC with smaller values indicate better model fit.[35] We did

not rely on the chi-square test to examine model fit because current analyses used a large

sample size, and chi-square is sensitive to sample size.[36] Statistical inferences were based

on *P* values <0.05 and 95% confidence intervals (CIs).

RESULTS

Participant characteristics

Descriptive characteristics of the sample are provided in Table 1. The mean age of study

participants was 15.1 ± 1.8 years. Half of the sample was male (51.7%) and of White ethno-

racial background (52.5%). Participants who met the physical activity, screen time, and sleep

duration recommendations represented 21.3%, 33.8%, and 32.4% of the sample, respectively.

We found that only 4.7% of participants met all three recommendations, whereas 38.9% met

none of the recommendations.

Confirmatory factor analysis (CFA) and internal consistency

Results from the CFAs for three competing models are presented in Table 2. Model 1 had all 6

items loading on a single factor of psychological distress (Figure 1), whereas Model 2 had the 6

items loading on 2 correlated first-order constructs of anxiety and depression (Figure 2). Model

3 had two factors of anxiety and depression that have a second-order structure representing

psychological distress (Supplemental Figure 1). While most of the indices were acceptable for

Model 1, it showed a slightly high RMSEA value of 0.065. However, compared to the single

factor model, the two-factor model was a better fit to the data, as defined in the Methods section

(RMSEA = 0.041; CFI = 0.995; TLI = 0.991; SRMR = 0.018). The model fit indices of the

second-order two-factor model (Model 3) of psychological distress indicated poor fit to the data.

Therefore, the 2-factor model (Model 2) was retained for subsequent analyses. The anxiety and

depression items demonstrated a Raykov composite reliability of 0.80 and 0.92, respectively, indicating a high level of internal consistency.

Meeting different movement behaviour combinations with anxiety and depressive symptoms

Results from structural equation modeling examining the associations of meeting different movement behaviour combinations with constructs of anxiety and depression are outlined in Table 3. Meeting all 3 recommendations was associated with lower anxiety ($\beta = -0.076$; p=0.028) and depressive symptoms ($\beta = -0.067$; p=0.028) relative to meeting none. Moreover, compared to meeting none of the recommendations, meeting the sleep duration recommendation only ($\beta = -0.135$; p<0.001), physical activity + sleep duration ($\beta = -0.084$; p=0.001), and screen time + sleep duration ($\beta = -0.157$; p=0.035) were associated with fewer symptoms of anxiety. However, meeting the physical activity only, the screen time only, and the physical activity + screen time recommendations were not associated with anxiety symptoms. Meeting all intermediate movement behaviour combinations was also associated with fewer depressive symptoms, except meeting the physical activity only and the screen time only recommendations. Meeting the screen time + sleep duration recommendations had the strongest relationship with anxiety ($\beta = -0.157$; p<0.001) and depressive symptoms ($\beta = -0.139$; p<0.001), followed by meeting the sleep duration recommendation only for both anxiety ($\beta = -0.135$; p<0.001) and depressive symptoms ($\beta = -0.106$; p<0.001). Overall, any of the combinations that included meeting the sleep duration recommendation showed better mental health outcomes. The combinations that did not include meeting the sleep duration recommendation (e.g., physical activity only, screen time only, physical activity + screen time – except for depressive symptoms) were not associated with better mental health indicators.

Results also showed that being male and having a higher perception of socioeconomic status were associated with lower anxiety and depressive symptoms. Being older was associated with greater anxiety and depressive symptoms. Being of non-White ethnoracial background was associated with greater depressive symptoms (Table 3). Results of sensitivity analysis excluding students aged 18 to 20 years showed similar results (not shown).

DISCUSSION

This study examined the association between meeting the 24-Hour Movement Guidelines and anxiety and depressive symptoms, as measured by the K6 in a province-wide representative sample of Canadian students in grades 7 through 12. In order to achieve this objective, we first confirmed the factor structure of the K6 psychological distress scale. Our analysis suggested a two-dimensional structure of the K6 that assesses symptoms of depression and anxiety. We found that after adjusting for confounders, meeting all 3 movement behaviour recommendations was associated with lower anxiety and depressive symptoms. However, this association appeared to be mainly driven by meeting the sleep duration recommendation, and to a lesser extent recommendation for screen time + sleep duration. Meeting the sleep duration recommendation alone was as beneficial for the outcomes as meeting all 3 recommendations (i.e. getting sufficient sleep + sufficient physical activity + low screen time).

Our results are consistent with previous studies that showed that meeting all 3 movement behaviour recommendations is associated with lower risk of depressive symptoms. In a large and nationally representative sample of nearly 60,000 US adolescents from the 2011-2017 cycles of the Youth Risk Behaviour Surveillance Survey, Knell et al.[37] found that meeting all 3 movement behaviour recommendations was associated with lower odds of depressive symptoms among adolescents. Similarly, Pearson et al.[38] found that meeting all 3 movement

behaviour recommendations was associated with lower odds of depressive symptoms in a sample of nearly 4,000 United Kingdom adolescents. These findings are in line with compelling evidence that accumulating sufficient physical activity,[39] limiting recreational screen time,[40] and getting enough sleep[41] are beneficially associated with a variety of physical, mental, and social health indicators among school-aged children and youth, and provide further support to the 24-hour guidelines.

Previous studies have mostly examined the relationship between meeting all 3 recommendations only and depressive symptoms, whereas it is uncertain whether meeting a particular combination would be more strongly associated with depressive symptoms than others. There is only one study (by Zhu et al.[42]) we are aware of that has examined the relationship between different combinations of movement behaviour recommendations with anxiety and depressive symptoms among adolescents. Indeed, Zhu et al.[42] found that meeting all three recommendations was associated with significantly lower odds of depression and anxiety compared with meeting none of the recommendations among adolescents, which is consistent with our findings. They also found that meeting all 3 recommendations was always the best choice among adolescents compared to meeting any other combinations.

In contrast, our results showed that meeting the sleep duration recommendation, and to a lesser extent meeting the screen time + sleep duration recommendation, was as beneficial for the outcomes as meeting all 3 recommendations. Our findings are somewhat consistent with those of previous studies indicating that adherence to the screen time and sleep duration recommendations have generally more benefits for adolescent mental health than meeting the physical activity recommendation. Indeed, Walsh et al.[43] and Guerrero et al.[44] found that meeting the screen time and sleep duration recommendations were strongly associated with

better cognitive function and less impulsivity in a representative sample of US children, respectively, while physical activity was not. It is possible that other types of physical activity not measured in the OSDUHS nor the ABCD, such light physical activity be favourably associated with mental health outcomes. Regardless, physical activity should not be neglected, as it has proven to offer a variety of benefits on adolescent physical, mental, and social health.[39] Furthermore, previous evidence has shown that physical activity may prevent depression and/or alleviate its symptoms in children and adolescents.[45-47] Given that excessive screen time, particularly around bedtime, has been identified as an important contributor to short sleep duration among adolescents,[48,49] it is important to address both screen time and sleep duration for mental health benefits. Future research, particularly from longitudinal studies, is needed to disentangle these findings and to confirm if getting enough sleep would result in subsequent better mental health.

Sleep duration is the behaviour that plays a bigger role in the present study. This not surprising because sleep is well known as an essential component of healthy development and is required for optimal physical and mental health.[50] Our results suggest that adherence to the sleep duration recommendation could be a good behavioural target to prevent anxiety and depressive symptoms among adolescents. However, short sleep duration is increasingly widespread among adolescents.[51] This supports the need for effective sleep intervention programs such as school-based sleep programs, which have shown potential long-term benefits.[52] Several possible mechanisms could explain the associations of sleep duration with anxiety and depressive symptoms. Short sleep duration affects brain activity and neurochemicals that regulate mood and thinking.[53] It is associated with greater stress reactivity within the hypothalamic-pituitary-adrenal axis, thus increasing the risk of psychopathological disorder.[54] Finally, it can make the maintenance of a healthy lifestyle, such as physical activity, more difficult because of subsequent daytime sleepiness, fatigue, and tiredness.[55,56]

Our results further indicated that being male and having a positive perception of socioeconomic status were associated with lower anxiety and depressive symptoms, whereas being older was associated with greater anxiety and depressive symptoms. These findings are consistent with the current literature indicating that females are more likely than males to have mental health problems,[57] and that the latter increase with age.[58] The findings that having a positive perception of socioeconomic status was associated with lower anxiety and depressive symptoms is also consistent with previous research indicating that subjective SES is related to aspects of adolescent health, and could play an important role in buffering the risk of mental health problems.[59-61] It is also possible that students who have good mental health tend to report higher levels of subjective SES. Finally, being of non-White ethnoracial background was associated with greater depressive symptoms. These findings are not surprising because research has shown that being of non-White ethnic background is associated with more mental health problems.[62]

With regards to distress, although K6 consistently showed very good reliability (as measured by Cronbach's alpha) when treated as a simple continuous scale,[4,23] our results showed that a two-factor model (representing anxiety and depressive symptoms) of the K6 had a better fit. These findings are consistent with previous studies indicating that a two-factor model representing anxiety and depression fit the data best in young adults[27] and older adults.[63] The screening information derived from the two-factor structure allows one to ascertain whether anxiety and/or depressive symptoms are elevated, thus providing richer information to guide intervention efforts compared to its traditional use as a continuous score of distress.

Strengths and limitations

Strengths of this study include the use of a large and representative sample of adolescents, and an assessment of the factor structure of the K6. While others have treated the K6 as a single scale as originally designed, our results showed that a two-factor model (representing anxiety and depression) of the K6 fit the data better in our sample, information that is important to guide intervention strategies. Our study also highlights the importance of assessing different combinations of recommendations within the 24-hour movement guidelines, whereas previous studies examining the relationship between meeting the 24-hour movement guidelines and depressive symptoms among adolescents have mainly included meeting all 3 movement recommendations.[37,38] Lastly, the current study included a comprehensive set of covariates that statistically controlled for several confounding variables, strengthening the internal validity of the findings.

Our study has several limitations that should be recognized. First, the study is based on cross-sectional data and thus the temporal order of meeting the 24-hour movement guidelines and psychological distress cannot be determined. It is possible that anxiety and depressive symptoms may have preceded movement behaviours rather than the reverse. Longitudinal studies are necessary to confirm temporality. Second, analyses are based on self-reported measures, thus subject to desirability and recall biases. Third, because the OSDUHS is conducted among adolescents who are within the regular school system, it is possible that the excluded students, mostly from private and alternative schools, differ from other adolescents with regards to movement behaviours and experiences of vulnerability to mental health problems. However, this is unlikely to be an important limitation because the vast majority of adolescents in Canada attend publicly funded schools, and our sample represents approximately 93% of students.[21] Fourth, the present study could not examine whether the

observed associations varied with the severity of anxiety and depressive symptoms. This is an interesting research question that future research could answer. Fifth, it is worth mentioning that K6 measures anxiety and depressive symptoms, and it is not indicative of a diagnosed mental health disorder. Although they may indicate risk of a common mental disorder,[23] future research using diagnosed mental disorders is needed to examine the role of different combinations of movement behaviours. Sixth, it is possible that strength of associations reported herein are underestimated because the survey excluded adolescents who dropped out of school, the homeless and institutionalized youths. These excluded groups are well known to have greater risk of engaging in health compromising behaviours and experiencing mental health problems.[64,65] Finally, the possibility of residual confounding by unmeasured variable such as medication utilization that could influence both sleep duration and anxiety and depressive symptoms is not excluded.

Conclusion

To the best of our knowledge, the present study is among the first to demonstrate that meeting the 24-hour movement guidelines is associated with lower anxiety and depressive symptoms among adolescents. Our results further indicate that meeting the sleep duration recommendation could be the main driver of this association, and to a lesser extent meeting the screen time + sleep duration guidelines. Our findings provide further support for heightened efforts to encourage adolescents to meet these guidelines, particularly to get adequate sleep as a possible means to promote adolescent mental health. It is important to intervene during adolescence because it is when many mental disorders emerge for the first time.[66] Further research using a longitudinal design is needed to confirm temporality and to elucidate the mechanisms linking sleep duration to mental health of adolescents. Future studies are also needed to confirm the validity of the 2- factor structure of the K6 in large and representative

samples of youth.

DATA ACCESS

Our data cannot be made available in the manuscript, the supplemental files or a public repository due to the Centre for Addiction and Mental Health's and The Ontario Public and Catholic School Board's institutional Research Ethics Board agreements. Qualified, interested researchers may request access to the data at the Centre for Addiction and Mental Health.

CONFLICTS OF INTEREST

Mark Ferro and JianLi Wang serve on the editorial board of the Canadian Journal of Psychiatry. The remaining authors have no conflicts of interest to declare.

were not involved in study design; collection, analysis, and interpretation of data; writing the

report; or the decision to submit the report for publication.

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Table 1. Descriptive characteristics of the sample.

	Participants (N=6364)	
	Unweighted n (%)[1]	Weighted %[2]
Age (years)		
Mean (SD)	14.7 (1.8)	15.1 (1.8)
Missing	1 (<1)	<1
Sex		
Males	2754 (43.3)	51.7
Females	3610 (56.7)	48.3
Missing	0	0
Ethnoracial Background		
White	3624 (57.0)	52.5
Black	562 (8.8)	13.2
East/South-East Asian	555 (8.7)	8.2
South Asian	463 (7.3)	6.0
Other	1160 (18.2)	20.1
Missing	0	0
Subjective socioeconomic status		
Mean (SD)	7.0 (1.6)	6.9 (1.7)
Missing	155 (2.4)	4.3
BMI z-scores		
Mean (SD)	0.3 (1.1)	0.3 (1.2)
Missing	391 (6.1)	6.5
Meet the physical activity recommendation		
No	4,932 (77.5)	78.0
Yes	1,361 (21.4)	21.3
Missing	74 (1.1)	0.7
Meet the screen time recommendation		
No	4167 (65.5)	66.2
Yes	2197 (35.5)	33.8
Missing	0	0
Meet the sleep duration recommendation		
No	4173 (65.6)	65.9
Yes	2109 (33.1)	32.4
Missing	82 (1.3)	1.7
24-hour movement guideline combinations		
None	2417 (38.0)	38.9
Only physical activity	456 (7.2)	7.3
Only screen time	937 (14.7)	14.3
Only sleep duration	928 (14.6)	14.5
Physical activity + screen time	319 (5.0)	5.0
Physical activity + sleep duration	263 (4.1)	4.1
Screen time + sleep duration	593 (9.3)	8.8

Physical activity + screen time + sleep duration	308 (4.8)	4.7
Missing	143 (2.3)	2.3

SD = standard deviation.

Data are shown as unweighted count (unweighted percent)[1] or weighted percent[2] unless otherwise specified. The sample weights are applied to ensure that the data are representative of all Ontario students in grades 7–12 in publicly funded schools.

Table 2. Confirmatory factor analysis model fit indices.

|	Criterion	One Factor	Two Factor	Second-Order 2 Factor
Chi square		245.812	91.608	1733.467
df		9	8	9
p	≥0.05	< 0.001	< 0.001	< 0.001
RMSEA	≤0.06	0.065	0.041	0.174
90% CI		0.058 to 0.072	0.033 to 0.048	0.167 to 0.181
p		< 0.001	0.978	< 0.001
CFI	≥0.95	0.986	0.995	0.901
TLI	≥0.95	0.977	0.991	0.835
SRMR	≤0.06	0.028	0.018	0.079

df: degrees of freedom; RMSEA: root mean square error of approximation; CI: confidence interval; CFI: comparative fit index; TLI : Tucker–Lewis fit index; SRMR: standardized root mean square residual. *p <0.001.

Table 3. Standardized path coefficients between combinations of movement behaviour recommendations and anxiety and depressive symptoms (N =6,364).

| Path	β	SE	P	95% CI	R², %
Anxiety					20.7
24-hour movement guideline combinations					
Only physical activity	0.010	0.027	0.705	-0.03 to 0.06	
Only screen time	-0.042	0.037	0.256	-0.10 to 0.02	
Only sleep duration	-0.135	0.024	**<0.001**	-0.17 to -0.10	
Physical activity + screen time	-0.045	0.022	0.141	-0.08 to 0.01	
Physical activity + sleep duration	-0.084	0.026	**0.001**	-0.13 to -0.04	
Screen time + sleep duration	-0.157	0.024	**<0.001**	-0.20 to -0.12	
Physical activity + screen time + sleep duration	-0.076	0.035	**0.028**	-0.13 to -0.02	
Covariates					
Age	0.190	0.032	**<0.001**	0.14 to 0.24	
Sex (reference = females)	-0.268	0.027	**<0.001**	-0.31 to -0.22	
Ethnoracial background (reference =White)	0.058	0.032	0.068	0.01 to 0.11	
Subjective socioeconomic status	-0.156	0.024	**<0.001**	-0.20 to -0.12	
Body mass index z-score	-0.009	0.029	0.767	-0.06 to 0.04	
Depressive symptoms					17.9
24-hour movement guideline combinations					
Only physical activity	0.001	0.030	0.978	-0.05 to 0.05	
Only screen time	-0.031	0.036	0.382	-0.09 to 0.03	
Only sleep duration	-0.106	0.025	**<0.001**	-0.15 to -0.07	
Physical activity + screen time	-0.054	0.017	**0.001**	-0.08 to -0.03	
Physical activity + sleep duration	-0.073	0.020	**<0.001**	-0.11 to 0.04	
Screen time + sleep duration	-0.139	0.025	**<0.001**	-0.18 to -0.10	
Physical activity + screen time + sleep duration	-0.067	0.031	**0.028**	-0.12 to -0.02	
Covariates					
Age	0.150	0.040	**<0.001**	0.08 to 0.22	
Sex (reference = females)	-0.244	0.025	**<0.001**	-0.29 to -0.20	
Ethnoracial background (reference =White)	0.078	0.029	**0.007**	0.03 to 0.13	
Subjective socioeconomic status	-0.176	0.028	**<0.001**	-0.22 to -0.13	
Body mass index z-score	-0.008	0.028	0.783	-0.05 to 0.04	

SE: standard error; CI: confidence interval. Meeting none of the recommendations represents the reference group.

Figure 1. Confirmatory factor analysis of one-factor model of psychological distress (N =6,364).
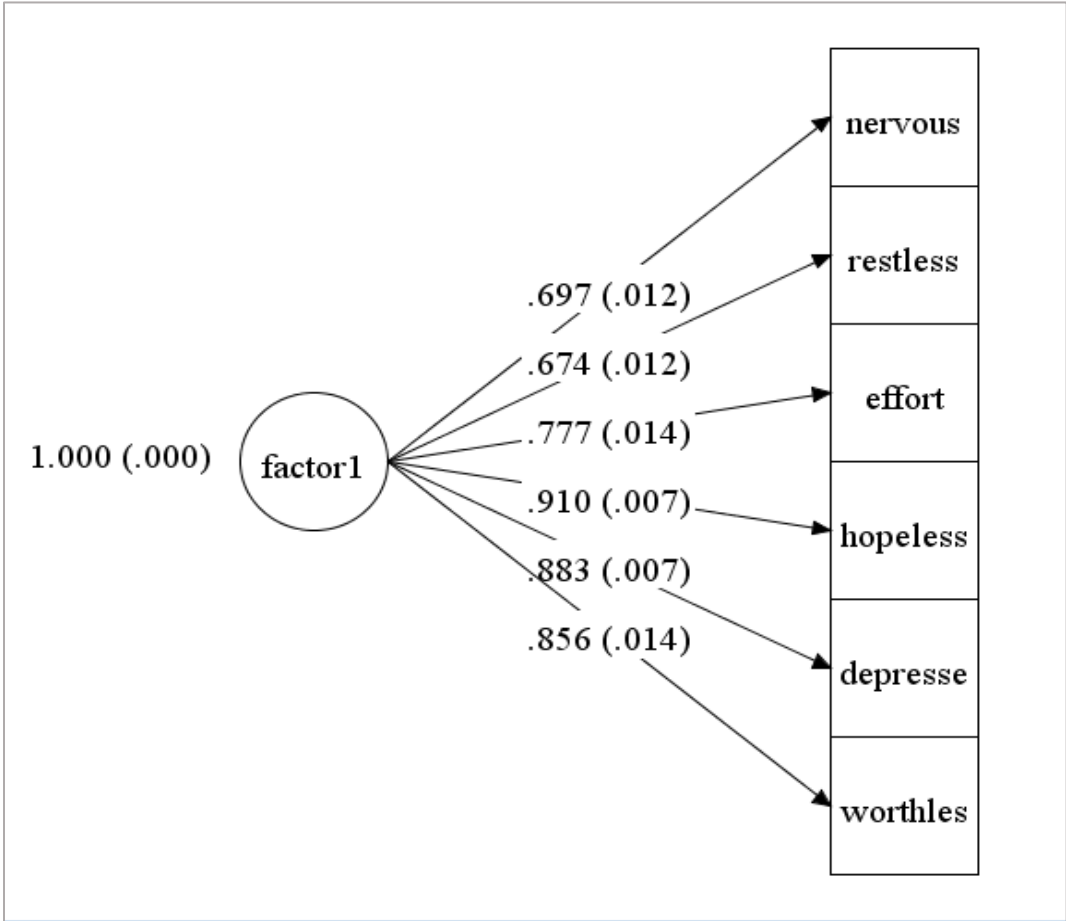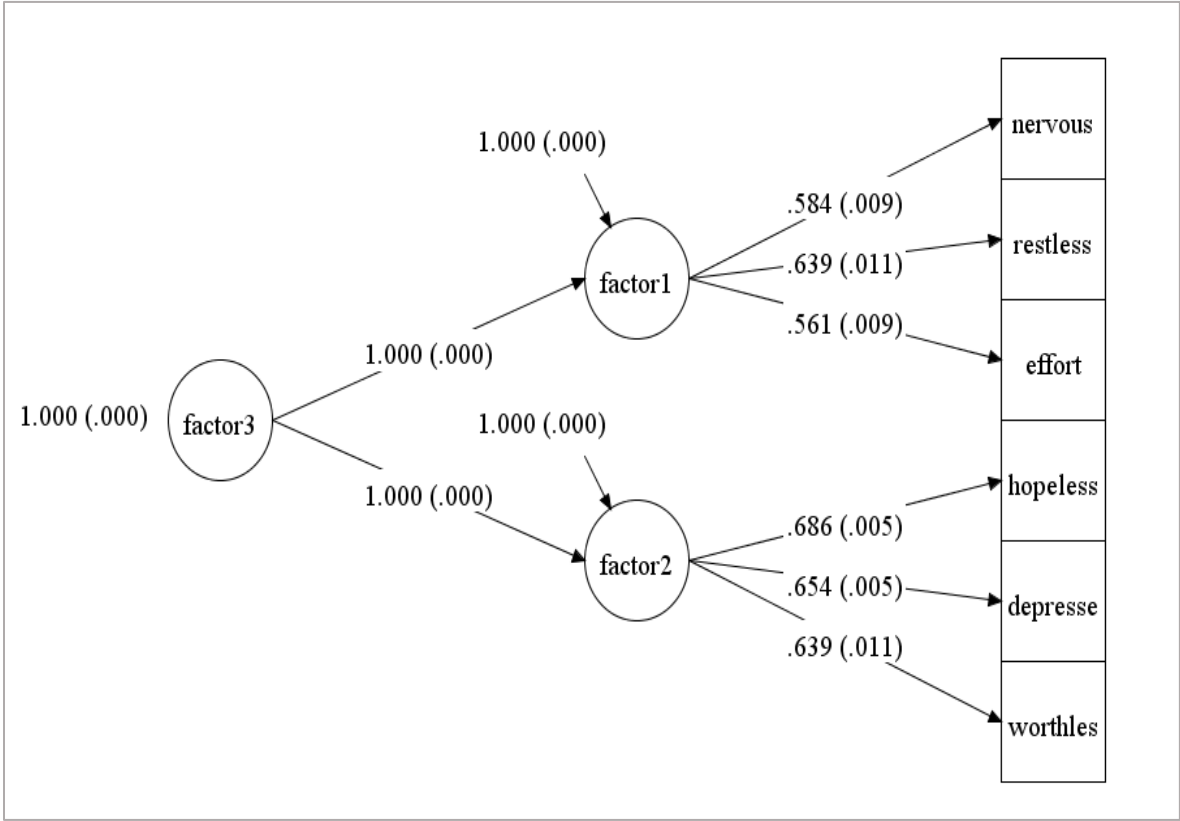

Factor 1 = Psychological distress

Figure 2. Confirmatory factor analysis of two-factor model of depression and anxiety (N =6,364).
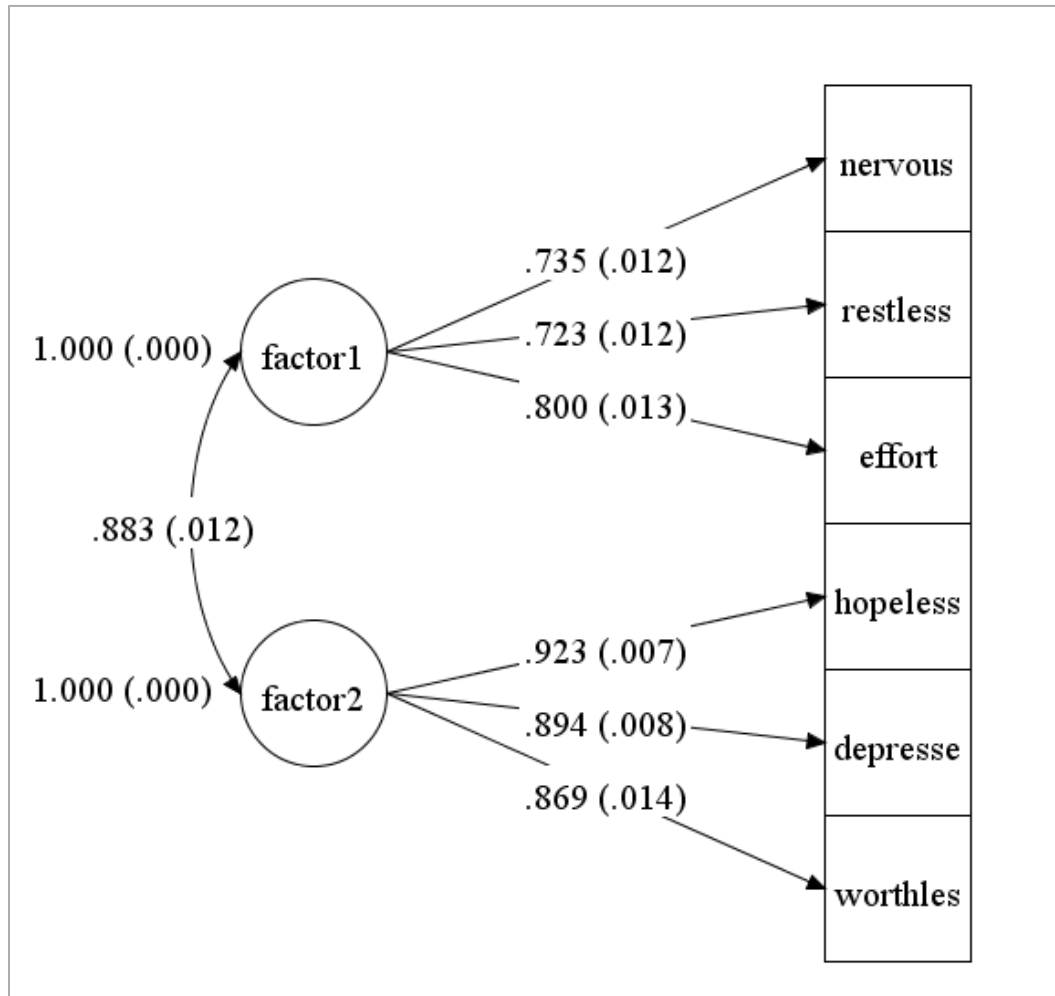
Factor 1 = Anxiety; Factor 2 = Depression.

Supplemental Figure 1. Confirmatory factor analysis of second-order two-factor model of psychological distress by depression and anxiety (N =6,364).

Factor 1 = Anxiety; Factor 2 = Depression; Factor 3 = Psychological distress.