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Kyan, Akira

Takakura, M.

Miyagi, M.

(Citation)
Public Health,213:117-123

(Issue Date)
2022-11-18

(Resource Type)
journal article

(Version)
Version of Record

(URL)
https://hdl.handle.net/20.500.14094/0100477533

Public Health 213 (2022) 117–123

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Original Research

Associations between 24-h movement behaviors and self-rated health: a representative sample of school-aged children and adolescents in Okinawa, Japan

A. Kyan [a, b, *], M. Takakura [b], M. Miyagi [c]

[a] Graduate School of Human Development and Environment, Kobe University, 3-11 Tsurukabuto, Nada-ku, Kobe City, Hyogo 657-8501, Japan
[b] Faculty of Medicine, University of the Ryukyus, 207 Uehara, Nishihara, Okinawa 903-0215, Japan
[c] Faculty of Education, University of the Ryukyus, 1 Senbaru, Nishihara, Okinawa 903-0213, Japan

ARTICLE INFO

Article history:
Received 15 May 2022
Received in revised form
5 August 2022
Accepted 12 October 2022

Keywords:
Physical activity
Screen time
Sleep
Perceived health
Adolescent

ABSTRACT

Objectives: This study aimed to determine the associations between adherence to 24-h movement behavior guidelines and self-rated health (SRH) among Japanese adolescents according to their age group.
Study design: This was a cross-sectional study.
Methods: Probability proportional sampling data, which were collected from six regions of Okinawa Prefecture, Japan, considering the number of schools, included 2408 fifth-grade students (aged 10–11 years) in 31 elementary schools and 4360 eighth-grade students (aged 13–14 years) in 30 junior high schools. SRH, moderate-to-vigorous physical activity (MVPA), screen time (ST), sleep duration, and confounding factors (sex, weight status, family affluence, parental support, school satisfaction, and school demands) were self-reported.
Results: The logistic regression models showed that adherence to ST and sleep recommendations in elementary school students was associated with a high prevalence of good health only, whereas adherence to only MVPA, only sleep, ST and sleep, MVPA and sleep, and all three recommendations were associated with a high prevalence of good health among junior high school students. All combinations that included achievement of the recommended sleep duration were associated with SRH.
Conclusions: Achieving 24-h movement behavior guidelines, particularly sleep recommendations, is associated with better perceived health in school-aged children, especially in adolescents.

Introduction

Twenty-four-hour daily activities consist of physical activity (PA), sedentary behavior, and sleep, which are complementary such that if one increases, another will decrease.[1] The associations between each of the three behaviors and various adolescent health indicators have been recognized separately. Recently, they have been redefined as “Movement Behavior (MB)” when the three behaviors are combined,[2] and evidence of their health effects has been accumulating over the decade.[3] Canada and Australia have launched guidelines for children and adolescents that specify the recommended duration of each behavior: 24-hour MB guidelines (24-h MBGs).[2,4] These guidelines recommend having at least 180 min of PA daily, with 60 min of moderate-to-vigorous intensity PA (MVPA), no more than 2 h of screen time (ST) per day, and at least 8–10 h of sleep (9–11 h for those aged 5–11 years).[2,4] Asia-Pacific region is also discussing to develop the similar guidelines.[5]

According to a recent systematic review,[3] 20 studies from 14 countries (all Western countries except Korea, China, and India) have been published as of January 2020, and favorable associations between adherence to 24-h MBGs and adolescents' physical health (e.g. cardiometabolic health, physical fitness, obesity) and mental health (e.g. global cognition, health-related quality of life) have been reported. However, as exemplified by the fact that most studies in this review are from Western countries, evidence from Asian countries is lacking. In particular, only two studies have examined the association between 24-h MBGs and physical health

* Corresponding author. Graduate School of Human Development and Environment, Kobe University, 3-11 Tsurukabuto, Nada-ku, Kobe city, Hyogo 657-8501, Japan. Tel and Fax: +81 78 802-7721.
E-mail address: a-kyan@pony.kobe-u.ac.jp (A. Kyan).

https://doi.org/10.1016/j.puhe.2022.10.012

in Japan.[6,7] Although they have almost replicated Western countries' evidence, the combinations including ST recommendations were associated with a low risk of overweight/obesity,[7] and meeting the MVPA recommendation was associated with greater aerobic fitness and muscle endurance,[6] no study has reported the association between meeting 24-h MBGs and other health outcomes among the Japanese adolescent population. Accumulation of evidence on various health indicators as outcomes is necessary to determine whether it is appropriate to promote this guideline for Japanese adolescents.

Self-rated health (SRH) is an important epidemiological indicator of health status. It is well known that SRH reflects an individual's holistic or summarized self-concept based on social, psychological, and health aspects.[8] Moreover, SRH in young individuals have been suggested to be an independent predictor of mortality, despite the inclusion of numerous specific health status indicators and other relevant covariates known to predict mortality.[9] Therefore, identifying correlates associated with SRH in adolescents is important from a public health perspective. Even from a global research trend, some studies have reported that adequate MVPA and sleep and low ST are separately associated with better SRH,[8,10] yet only one study has examined the relationship between adherence to 24-h MBGs and SRH.[11] A Canadian adolescent study reported that those who achieved any of the recommendations were more likely to have good SRH than those who achieved none, dose-response gradient between an increasing number of MB recommendations met and better health indicators.[11] However, this study did not consider psychosocial factors, such as family, school climate,[12,13] and school demand, which can confound health status during this age period. It is debatable whether the same results were obtained after adjusting for crucial confounding factors. Moreover, because Japanese adolescent populations have different social, cultural, and health systems, personality traits, and physiques,[14–16] it is necessary to confirm the replication of evidence from Western countries.

Therefore, the present study aimed to examine the association between adherence to 24-h MBGs and SRH among Japanese adolescents. Because age-related increases in poor SRH have been observed during adolescence,[17] we examined whether the association differs according to age group and which combinations of 24-h MBGs were associated with poor SRH.

Methods

Study participants and procedures

This study included 2408 students (52.2% girls) who were enrolled in the fifth grade (aged 10–11 years) in 31 elementary schools and 4360 students (49.9% girls) who were enrolled in the eighth grade (aged 13–14 years) in 30 junior high schools in Okinawa Prefecture. Okinawa Prefecture is located in the southwesternmost part of Japan and has a population of 1.4 million people. The number of fifth-grade elementary school and eighth-grade junior high school students during the survey period were 16,339 and 16,922, respectively.[18] Okinawa Prefecture had 268 public elementary schools and 148 junior high schools during the survey period and was divided into six regions (four situated on Okinawa Island and two on remote islands).[18] The participants' data were collected through cluster sampling with schools as one unit. Schools included in this study were selected from each school-aged group with a probability that was proportional to the number of schools within the school-aged group and regions in the prefecture by the education board. A staff of the Okinawan Prefectural Board of Education selected the participating schools.

Classroom teachers distributed self-administered questionnaires following written instructions provided by the researchers. The questionnaire consisted of questions about sociodemographic attributes, psychosocial school environment, lifestyle, and health status. Anthropometric status data were obtained from school records at the end of the first semester in mid-July. Before conducting the survey, passive informed consent was obtained from parents or guardians. The students were requested to take home an informed consent form, which provided information regarding the ethical considerations of the study. Participation of the students was voluntary, and the confidentiality of the participants was ensured. The students were free to decline to participate in the study. The parents/guardians were given the phone number and email address of the principal investigator (M.M.) and had the opportunity to withdraw their children from the study by declaration. All assenting students who provided their parents' consent were requested to complete and return the questionnaire sealed in an unmarked envelope to ensure the confidentiality of their responses.

Self-rated health

SRH was assessed by answering five possible answers ("Strongly disagree," "disagree," "neither agree nor disagree," "agree," "Strongly agree") to "I'm healthy at present." Although measurement items for SRH vary and are not standardized,[19] questions almost identical to those used in this study are included in the standard Health Behavior in School-Children (HBSC) questionnaire, which is a reliable and validated measuring tool.[20] Similar questions are used in Japanese national surveys.[21] Participants' answer was recoded into dichotomous variable with categories that "strongly disagree," "disagree," and "neither agree nor disagree" were as "perceived poor health," whereas "agree" and "strongly agree" were as "perceived good health."

Physical activity

PA was measured using Patient-Centered Assessment and Counselling for Exercise plus Nutrition. This was developed to identify the extent to which young people achieved the current guidelines, which is a minimum of 60 min of MVPA per day of the week. The assessment tool has been confirmed to be valid and reliable for measuring PA in diverse populations, including Japanese adolescent.[22–28] In the questionnaire, PA refers to any activity that increased the heart rate and makes an individual feel out of breath for some time. PA can include sports, school activities, playing with friends, or walking to school. Examples of PA include running, brisk walking, rollerblading, biking, dancing, skateboarding, swimming, soccer, basketball, football, and surfing. To verify the consistency of the most recent PA, participants were dichotomized into either active or inactive based on whether they achieved seven days per week of 60 min MVPA based on the calculated average score of the responses for the last week and the typical week. Specifically, if the average number of days was less than daily, the participant was categorized as inactive.[2]

Screen time

ST was assessed by questioning television (TV) viewing and computer use separately. These questions were formulated as follows: "How many hours a day do you usually spend watching TV at home on weekdays?"; "How many hours a day do you usually use your personal computer (including smartphone or tablet), excluding the time when these devices were used for learning, to play computer games (such as TV game, computer game, and mobile game) at home on weekdays?" Possible answers to each

question were "never," "less than 1 h/day," "1–2 h/day," "2–3 h/day," "3–4 h/day," "4–5 h/day," and "more than 5 h/day." Although there are no standardized ST questionnaire items, many previous studies have adopted the items of time spent watching TV and using smartphones, tablets, and PCs as an indicator, which is comparable to our study.[29] Similar questions have also been used in national surveys in Japan.[30,31] The participants' answers were recoded in minutes of TV viewing and computer use per day using the midpoint method. We summed up both means and categorized the participants based on the cutoff of 2 h of recreational ST.[2]

Sleep duration

Sleep duration was assessed by questioning bedtime and awakening hours on weekdays. Participants were asked to report the times they typically turned out to go to sleep and when they woke up in the morning on weekdays. The question regarding bedtime hours was formulated as follows: "What times do you usually go to bed on weekdays?" Possible answers were "before 8 p.m." "9–10 p.m." "10–11 p.m." and "after 11 p.m." Regarding wake up time, the question was as follows: "What times do you usually go to bed on weekday?" Possible answers were "before 6 a.m." "6–6.5 a.m." "6.5–7 a.m." "7–7.5 a.m." and "after 7.5 a.m." Similar questions have also been used in national surveys in Japan.[32] The answer categories were recoded in minutes using the midpoint method. Sleep duration was calculated by subtracting wake up time from bedtime and then the participants were grouped based on whether or not they had a sleep duration that was within the recommended range (9.0–11.0 h/night for 6- to 13-year-olds; and 8.0–10.0 h/night for 14- to 17-year-olds).[2] Participants whose sleep duration was less than or greater than the recommended range were not considered to have met the recommended sleep duration.

Confounding factors

Sex, weight status, socio-economic status (SES; family affluence), parental support, school satisfaction, and school demand were considered as potential confounding factor.[33,34] We referred to the question items of family affluence, parental support, school engagement, and school demand used in the HBSC survey.[20]

Weight status was calculated using the height and weight data, which were obtained from school records taken by school nurse–teachers as part of the standard procedure carried out every April in Japan. Weight status was classified based on Japanese cutoffs for weight status that were established based on national reference data for Japanese children as normal weight, overweight/obesity (≥20%), or thin (≤−20%).[35] The calculation details are described in the appendix.

SES was assessed using the Family Affluence Scale Second Version (FAS-II). FAS-II is a measurement of family wealth used in the HBSC survey in 2009/2010.[20] The items, response categories, codes, and analysis strategy of FAS-II used in the present study are as follows: "Does your family own a car, van or truck?" Response categories were "No," "Yes, one" and "Yes, two or more." "Do you have your own bedroom for yourself?" Response categories were "No" and "Yes." "During the past 12 months, how many times did you travel away on holiday with your family?" The response categories were: "Not at all," "Once," "Twice," and "More than twice." "How many computers does your family own?" Response categories were "None," "One," "Two," and "More than two." According to a previous study,[36] a composite FAS score was calculated for each respondent based on their answers to these four items. Three groups were categorized in terms of the composite FAS score, in which FAS low (score = 0–3) indicated low affluence, FAS medium (score = 4, 5) indicated moderate affluence, and FAS high (score = 6, 7) indicated high affluence.

Parental support was measured using one question: "If I have problems at school, my parents are ready to help." The possible answers were "strongly disagree," "disagree," "neither agree nor disagree," "agree," and "strongly agree." Participants' answer was recoded into dichotomous variable with categories, such that "strongly disagree," "disagree," and "neither agree nor disagree" were as "unsupportive parents," whereas "agree" and "strongly agree" were as "supportive parents."

School satisfaction was measured by one question item: "How do you feel about school at present?" Possible answers to school engagement were, "I don't like it at all," "I don't like it very much," "I like it a bit," and "I like it a lot." Participants' answers were recoded into dichotomous variables with categories that "I don't like it at all" and "I don't like it very much" were as "unsatisfied with school," whereas "I like it a bit" and "I like it a lot" were "satisfied with school."

School demand was measured by one question: 'How pressured do you feel by the schoolwork you have to do?' Possible answers were "a lot," "some," "at little," and "not at all." Participants' answer was recoded into dichotomous variable with categories that "not at all" and "at little" were as "non-demanded," whereas "some" and "a lot" were as "demanded."

These school-related psychosocial measurements have confirmed their reliability and validity in capturing the social context of health in adolescents and have been included as part of an international standard questionnaire, that is, the HBSC survey.[20]

Statistical analyses

Students were classified into one of the following eight categories of guideline adherence: none, only sleep, only ST, only MVPA, sleep and ST, sleep and MVPA, ST and MVPA, or all three guidelines. Descriptive statistics were calculated for all the variables. Logistic regression models were used to examine the association between compliance with 24-h MBGs and SRH. Crude and adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. Sex, weight status, SES, parental support, school satisfaction, and school demand were included as covariates to adjust for potential confounding factors. For any specific combination of 24-h MBGs, those who did not meet the recommendation were placed in the reference group.[37]

Intraclass correlations, which indicate the proportion of the total variance in SRH attributable to schools, were 1.0% and 0.7% for elementary and junior high schools, respectively. Thus, we proceeded with the analysis without considering school variance.

Multivariable multiple imputation was used to complement the missing values, as the missing data were confirmed to have originated completely at random by the Little's missing completely at random test ($P < 0.001$). We generated five imputed data sets and combined the estimates using Rubin's rules.[38] Rubin's multiple imputation method is a statistical estimation of missing value data that creates multiple data sets with missing value imputations and integrates the results.

The variables in the imputation model were SRH, MVPA, ST, sleep, sex, height, weight, family affluence scale score, parental support, school satisfaction, and school demand.

Results

Table 1 lists the characteristics of the sample obtained using the imputed data set. The sample of junior high school students was larger than that of elementary school students because of the larger enrollment per grade. The prevalence of good health among

elementary and junior high school students was 91.3% and 88.4%, respectively. Elementary school students had a higher percentage of non-adherence to all recommendations (39.2%) than junior high school students (10.4%). In addition, adherence to the recommendation of only MVPA, only ST, and MVPA and ST was higher in elementary school students, and adherence to the recommendations of only sleep, MVPA, and sleep was higher in junior high school students. There were no differences in adherence to ST and sleep recommendations in each age group. The preimputed number of samples and the distribution of SRH depending on each independent variable are listed in e-Table 1 and e-Table 2, respectively (appendix).

Table 2 shows the results of the logistic regression model that examined the associations between the compliance of 24-h MBGs and SRH among elementary school students and junior high school students, respectively. The reference was the relationship between none of the adhered 24-h MBGs and the prevalence of good health. Among elementary school students, the adhered ST and sleep recommendation was associated with a high prevalence of good health (OR 2.24, 95% CI, 1.20–4.16). Among junior high school students, adherence to only MVPA (OR 3.41, 95% CI, 1.52–7.66), only sleep (OR 2.87, 95% CI, 2.22–3.72), ST and sleep (OR 4.12, 95% CI, 2.80–6.05), MVPA and sleep (OR 5.44, 95% CI, 3.72–7.93), and all three recommendations (OR 5.29, 95% CI, 2.83–9.88) were associated with a high prevalence of good health. These associations were continuously observed when taking into account confounding factors were considered.

Table 1
Participants' characteristics using the five imputed data sets.

Variables	Elementary school student		Junior high school students	
	Total		Total	
	n	%	n	%
Total	2408	100.0	4360	100.0
Sex				
Male	1152	47.8	2186	50.1
Female	1256	52.2	2174	49.9
Self-rated health				
Poor health	208	8.7	504	11.6
Good health	2200	91.3	3856	88.4
SES (FAS-II)				
Low	366	15.2	703	16.1
Middle	1152	47.8	2055	47.1
High	890	37.0	1602	36.7
Weight status				
Thin	66	2.7	84	1.9
Normal weigh	2076	86.2	3926	90.1
Overweight/obesity	267	11.1	350	8.0
School demands				
Non-demanded	1001	41.6	705	16.2
Demanded	1407	58.4	3655	83.8
Parental support				
Unsupportive parents	611	25.4	1654	37.9
Supportive parents	1797	74.6	2706	62.1
School satisfaction				
Unsatisfied with school	320	13.3	772	17.7
Satisfied with school	2088	86.7	3588	82.3
Compliance prevalence of 24-hour movement behavior				
None	944	39.2	454	10.4
MVPA	134	5.5	78	1.8
Screen time	242	10.0	77	1.8
Sleep	629	26.1	2227	51.1
MVPA and screen time	48	2.0	20	0.5
Screen time and sleep	276	11.5	555	12.7
MVPA and sleep	79	3.3	745	17.1
ALL three	57	2.4	203	4.7

FAS-II, Family Affluence Scale Second Version; MVPA, moderate-to-vigorous physical activity, SES, socio-economic status.

Discussion

This large-scale cross-sectional study, using a representative sample of adolescents in Okinawa, showed that achieving ST and sleep recommendations for elementary school students and all recommendations except ST, MVPA, and ST for junior high school students were associated with high SRH. It is noteworthy that the achievement of 24-h MBGs was often associated with SRH in junior high school students and that all combinations that included the achievement of the recommended sleep duration were associated with SRH. Based on these results, it can be interpreted that the achievement of 24-h MBGs, especially sleep duration, in junior high school students may be more important to their perceived health than that in elementary school students.

A Canadian adolescent study suggested that all of the recommendations are significant, but age-specific comparisons are impossible because this study analyzed adolescents aged 11 years to >20 years as pooled data.[11] In one study of US adolescents aged 6–11 years and those aged 12–17 years using depression as an outcome, older age was associated with the achievement of all recommendations, whereas younger adolescents showed only three recommendations (ST, ST and sleep, and PA and sleep).[39] Another study using data from 14 years in the United Kingdom also showed a significant association between meeting all three recommendations and depression.[40] According to 14 countries' global comparative study on the association between 24-h MBGs and health-related quality of life in children aged 9–11 years,[41] several counties did not detect the effect of achieving each recommendation. For example, none of the adhered recommendations was associated with health-related quality of life in China and Colombia, only sleep recommendations were associated with health-related quality of life in Brazil, and only ST and sleep were associated with health-related quality of life in Finland and India. Considering these previous findings and our results, the impact of the achieving 24-h MBGs on perceived health status, well-being, and quality of life might be more salient in older adolescents. Further research is needed, as few studies have discussed age-related differences.

The results of junior high school students' increasing importance of achieving 24-h MBGs to SRH are slightly different from the Western evidence that all 24-h MBGs achievements are associated with SRH.[11] Adequate sleep time could be crucial for SRH rather than other recommendations in Japanese junior high school students because all combinations that included achieving the recommended sleep duration were associated with SRH in our results. In other words, it should be recommended that MB balances the promotion of MVPA and ST limitations during the day while focusing on getting adequate sleep at night. It has been recognized that sleep is an important factor for SRH.[42] A study of Japanese adolescents also showed that getting approximately 8 h of adequate sleep is associated with lower depression/anxiety.[43] Our findings extend the understanding of the importance of sleep by examining different combinations of meeting the 24-h MB recommendations.

Our result regarding the achievement of the MVPA and ST recommendation was not associated with SRH and was contrary to the findings of previous studies.[44] Although it supports that adequate sleep is paradoxically important, achieving ST only shows an insignificant effect. This may be due to different health effects depending on the type of ST. A recent Japanese study,[45] which examined the association between various types of ST (TV, social media, online games, and online videos) and depression, showed different results according to ST type: a negative impact was observed in social media use or playing online games, but a positive impact was shown in watching TV or online video. Currently, the differences in the health effects of different types of STs are already being discussed.[46] However, further evidence is required.

Table 2
Logistic regression examining the associations of movement behavior combinations with self-reported health.

Variables	Elementary school students				Junior high school students			
	Not adjusted model		Adjusted model		Not adjusted model		Adjusted model	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
None	Reference		Reference		reference		Reference	
MVPA	1.59	0.75–3.36	1.86	0.85–4.03	3.41	1.52–7.66	2.79	1.22–6.36
Screen time	1.33	0.77–2.28	1.19	0.68–2.08	1.48	0.79–2.76	1.52	0.80–2.91
Sleep	1.10	0.77–1.57	1.08	0.74–1.56	2.87	2.22–3.72	2.32	1.77–3.04
MVPA and screen time	2.38	0.57–9.99	2.51	0.58–10.87	2.68	0.60–11.88	1.88	0.42–8.48
Screen time and sleep	2.24	1.20–4.16	2.02	1.07–3.82	4.12	2.80–6.05	3.34	2.25–4.98
MVPA and sleep	6.89	0.92–51.43	6.92	0.91–52.96	5.44	3.72–7.93	4.14	2.80–6.12
All three	0.62	0.28–1.36	0.55	0.24–1.25	5.29	2.83–9.88	3.88	2.05–7.36
Sex			1.38	1.00–1.90			0.96	0.79–1.18
Weight status			0.64	0.42–0.97			0.65	0.48–0.88
SES			1.34	1.07–1.68			1.03	0.89–1.19
School demand			1.40	1.01–1.96			1.46	1.07–200
Family support			2.41	1.75–3.33			1.88	1.53–2.31
School satisfaction			2.71	1.89–3.88			2.63	2.11–3.29

OR, odds ratio; CI, confidence interval; MVPA, moderate-to-vigorous physical activity; SES socio-economic status.

Limitations

This study had several limitations. As the study participants were from only one prefecture, the generalizability of the present findings to adolescents in Japan as a whole may be limited. However, ST and sleep duration among elementary and junior high school students in Okinawa Prefecture were almost the same as the national averages, according to the 2015 national survey data.[31] The proportion of participants who reported good SRH in this study was also similar to the National Sports-Life Survey of Teens 2015, by the Sasakawa Sports Foundation[47] based on a nationwide two-stage stratified random sampling. In contrast, while comparable data for MVPA are only available for 2019,[48] the proportion of recommendation achievement is higher in our study. Further research is needed to confirm that our results can be replicated both nationally and internationally.

In addition, causality could not be drawn from the present study because of the use of a cross-sectional design. There may be those who cannot engage in these healthy behaviors because of poor health. Therefore, further longitudinal studies are required. Recent studies have pointed out the need for compositional analysis for isolating the time use characteristics of each behavior based on MB data measured quantitatively by accelerometers.[49] Future studies also need to examine the association between MB composition and SRH.

Conclusion

Our study found the importance of PA, ST, and especially sleep for SRH. These MBGs were more strongly associated with SRH than with sociodemographic and psychosocial environmental factors. This means that the daily MB may be one of the crucial signals of a child's subjective health status. To maintain and promote children's health, health behaviors should be monitored regularly, and key stakeholders, including public health authorities, health service providers, schools, parents, and adolescents themselves, should take necessary measures (developing laws, cultivating supportive communities, schools, and home environments, and providing education) without delay.

Author statements

Ethical approval

The Institutional Review Board of the University of the Ryukyus approved the study protocol (authorization number: 253).

Funding

This study was supported by the Grant-in-Aid for Scientific Research (JSPS KAKENHI Grant Number JP15K12725 and 20K13966) from the Japan Society for the Promotion of Science and Advanced Medical Research Support Project of University of the Ryukyus.

Competing interests

The authors declare no other conflict of interests.

Authors' contributions

A.K. performed the statistical analyses and drafted the manuscript. M.T. designed, reviewed, and edited the article and contributed to the discussion. All authors have read and approved the final article. M.M. designed and executed data collection and contributed to the discussion.

Acknowledgments

The authors would like to thank all students and teachers who agreed to participate in this study. We would like to thank Editage (www.editage.com) for English language editing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2022.10.012.

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