Associations of Meeting 24-hour Movement Guidelines with Stress and Self-rated Health among Adults: Is Meeting more Guidelines Associated with Greater Benefits?

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Abstract

Background: Several countries have recently issued 24-hour movement guidelines for adults. From a public health perspective, it is important to explore the health benefits of meeting the 24-hour movement guidelines. This study, therefore, aimed to explore the associations of meeting the 24-hour movement guidelines with stress and self-rated health among adults, and whether the likelihood of favourable outcomes increases with the number of movement guidelines met.

Methods: A total of 2476 adults participated in our survey. The participants were categorised depending on whether they met the combined 24-hour movement guidelines, any combination of two individual guidelines, or any individual guideline. The associations of meeting the movement guidelines with stress and self-rated health were analysed using ordinal logistic regression models.

Results: Significantly lower odds of reporting higher frequency of stress were found for those who met the combined 24-hour movement guidelines (adjusted odds ratio [OR] = 0.45; 95% confidence interval [CI]: 0.32, 0.63; $p < 0.001$), any combination of two guidelines (OR range: 0.48 – 0.63; $p < 0.05$ for all), and sleep guideline only (OR = 0.51; 95% CI: 0.35, 0.75; $p = 0.001$). Significantly higher odds of reporting better self-rated health were found for those who met the combined 24-hour movement guidelines (OR = 2.94; 95% CI: 2.07, 4.19; $p < 0.001$), combination of MVPA and SB guidelines (OR = 2.33; 95% CI: 1.57, 3.44; $p < 0.001$), combination of MVPA and sleep guidelines (OR = 1.78; 95% CI: 1.23, 2.59; $p = 0.002$), and MVPA guideline only (OR = 2.24; 95% CI: 1.50, 3.36; $p < 0.001$). Meeting more guidelines was associated with greater odds of favourable outcomes (p for linear trend < 0.001).

Conclusion: Adults who meet the sleep guideline, any combination of two guidelines, or all three guidelines experience stress less frequently. Meeting the MVPA guideline alone or in combination with any other movement behaviour guideline was associated with better self-rated health. The likelihood of less frequent stress and better self-rated health increases with the number of guidelines met. These findings highlight the public health importance of encouraging adults to meet as many movement behaviour guidelines as possible.

Background

There has been a recent shift from studying the effects of each movement behaviour separately to simultaneously examining the effects of all movement behaviours that occur in a 24-hour day (1–6). This paradigm was motivated by the findings that sleep, sedentary behaviour (SB), and physical activity are associated with health (7, 8) and that the amounts of time spent in these behaviours are perfectly collinear parts of the 24-hour day – more time spent in one movement behaviour inevitably leads to less time spent in the remaining ones. The new paradigm has been widely accepted by researchers and international and national public health authorities. The World Health Organization and several countries have issued 24-hour movement guidelines (9–18). According to the novel 24-hour movement guidelines, adults should, for example, limit their SB to no more than eight hours per day, accumulate at least 150

minutes of moderate-to-vigorous physical activity (MVPA) per week, and sleep seven to nine hours a day (12).

Studies among children and youth have suggested that adhering to recommendations for a higher number of individual movement behaviours (e.g. for 3 vs for 2, or for 2 vs for 1) is associated with greater health benefits (19, 20). However, for adult populations, such evidence is scarce. Given that the 24-hour movement guidelines for adults have recently been issued in several countries, from a public health perspective it is important to explore whether meeting more movement behaviour guidelines is associated with greater benefits. According to the framework for Viable Integrative Research in Time-Use Epidemiology (VIRTUE), such associations should be explored for a range of health outcomes (2). For the purpose of this study, we selected stress and self-rated health as outcome variables, as they have often been explored in relation to movement behaviours.

Stress is commonly defined as a “physical, mental, or emotional strain or tension” (21). It can be understood as individual’s response to events that they experience as threatening to their well-being or overwhelming (22). Although it is a natural response, prolonged stress can have negative effects on health (23). Chronic stress can substantially alter nervous, cardiovascular, endocrine, and immune functioning, and it is associated with various chronic diseases, including coronary heart disease, stroke, depression, and anxiety (24–28). Frequent experience of stress is a pervasive issue: every third adult globally reports experiencing a lot of stress (29). Furthermore, stress is associated with movement behaviours (30–32). The relationship is considered to be bidirectional, with stress as a predictor of engagement in movement behaviours and engagement in movement behaviours as a predictor of stress. In particular, high stress seems to be associated with low levels of MVPA (32) and short sleep (31). Findings on the association between SB and stress are inconsistent (33).

Self-rated health is one of the most widely used measures in epidemiological studies (34). It represents one’s subjective evaluation of their own overall health status. Self-rated health is a strong predictor of mortality risk (35), and it was found to be consistent with the objective general health status (36). Findings from the World Health Survey suggested that the global prevalence of poor self-rated health is around 10% (37). Previous studies have found that high MVPA (38), low SB (39) and adequate sleep duration (40) are associated with better self-rated health. These relationships are also likely to be bidirectional (41).

Very few studies examined the associations of the 24-hour movement behaviour composition with stress and self-rated health (7, 8, 42). Previous studies that assessed combinations of movement behaviours in relation to stress have shown mixed findings. For example, Onodera et al. (43) found that reallocating time from SB to MVPA is associated with less stress. Oftedal et al. (44, 45) found a favourable association with stress for an overall ‘healthy’ combination of movement behaviours and dietary habits. Some studies did not find a significant association between stress and movement behaviour compositions (46, 47). Furthermore, studies on the association between movement behaviour composition and self-rated health suggested a positive role of MVPA (48) and light-intensity physical

activity (47). However, evidence on the association of adherence to the 24-hour movement guidelines with self-rated health and stress is scarce.

Therefore, the aim of this study was to explore the associations of meeting the 24-hour movement guidelines with self-rated health and the frequency of stress among adults. We focused on exploring whether the likelihood of favourable stress and self-rated health outcomes increases with the number of movement guidelines met. We hypothesised that meeting the combined 24-hour movement guidelines (i.e. recommendations for sleep, SB, and MVPA) is associated with better self-rated health and lower frequency of experiencing stress. We also hypothesised that adhering to a higher number of individual recommendations is favourably associated with self-rated health and stress.

Methods

Data Collection and Participants

Data were collected from November 2019 to March 2020 using an online survey. Participants were recruited via mailing lists, daily newspapers, web-portals, and social media. The participation in the survey was voluntary and anonymous. All participants provided informed consent before commencing with the survey. The study was performed in accordance with the Declaration of Helsinki and it was approved by the Republic of Slovenia National Medical Ethics Committee (approval number: 0120–557/2017/4).

A total of 2476 participants agreed to participate in the study and completed the survey. The survey data were cleaned based on visual inspection of entered hours (hh:mm) and automated detection of participants who did not use web-based sliders for responding to specific questions (which indicated that they did not understand how to respond to these questions or did not want to respond). This led to exclusion of 79 participants. Additionally, 64 participants were excluded from this analysis, because they were under the age of 18 years, they did not provide information on socio-demographic characteristics, or they provided invalid data. Data from 2333 participants were included in the final analysis.

Measures

Movement behaviours. The amounts of time spent in MVPA, SB, and sleep were assessed using the Daily Activity Behaviours Questionnaire (DABQ). This 31-item questionnaire asks about MVPA and SB (in the work, transport, domestic, and leisure-time domains) and sleep in the past seven days. According to Landis and Koch (49), the test-retest reliability of DABQ estimates is moderate (quadratic weighted Cohen's kappa [κ_w] = 0.58 for sleep, κ_w = 0.56 for SB, and κ_w = 0.47 for MVPA), the agreement of sleep estimates from DABQ and a time-use diary is substantial (κ_w = 0.66), and the agreement between DABQ and accelerometer-inclinometer estimates is moderate for SB (κ_w = 0.41) and fair for MVPA (κ_w = 0.32).

Based on their responses to DABQ, participants were categorised into the following eight groups: 1) meeting overall, combined 24-movement guidelines; 2) meeting sleep and MVPA recommendations; 3)

meeting sleep and SB recommendations; 4) meeting MVPA and SB recommendations; 5) meeting only sleep recommendation; 6) meeting only SB recommendation; 7) meeting only MVPA recommendation; and 8) not meeting any of the recommendations. The thresholds for meeting the recommendations were: at least 150 minutes of MVPA per week; less than eight hours of SB per day; and sleeping between seven and nine hours (7:00–9:59 h:mm) per day for adults and between seven and eight hours (7:00–8:59 h:mm) per day for older adults (12).

Outcomes. The outcome measures were self-rated health and frequency of stress. The question about stress was: “*How often do you feel tense, under stress, or great pressure?*” with the following response options: *never, very rarely, occasionally, often, and every day* (50). The question about self-rated health was: “*In general, how would you rate your current health status?*” with the following response options: *very good, good, fair, bad, and very bad*. The question has been validated before (36), showing a strong association with objectively assessed general health status, morbidity (51), and mortality (35) in the general population. Also, test-retest reliability was shown to be good-to-excellent (52).

Socio-demographic and lifestyle characteristics. We assessed age, sex, body mass index (BMI; calculated from self-reported body height and body weight, and categorised as *underweight or ‘normal’ weight* [$< 25 \text{ kg/m}^2$] / *overweight* [25.0 kg/m^2 to 29.9 kg/m^2] / *obese* [$\geq 30 \text{ kg/m}^2$]), level of education (*primary or secondary education* / *higher education*), self-reported socio-economic status (*high or very high* / *middle* / *low or very low*), employment status (*employed in non-shift work* / *employed in shift work* / *unemployed*), place of residence (*urban* / *rural*), living arrangement (*with partner* / *without partner*) and smoking status (*not smoking* / *smoking*).

Statistical Analysis

The data were processed and analysed using R version 4.0.2 (53) and R Studio 1.3.959 (54) with the packages *dplyr* (55), *ggplot2* (56), *janitor* (57), *skimr* (58), *rstatix* (59), *MASS* (60), *brant* (61), and *generalhoslem* (62). Absolute and relative frequencies (%) were calculated for all variables.

The associations of meeting the movement guidelines with stress and self-rated health were analysed using ordinal logistic regression (proportional odds) models with stress and self-rated health as outcome variables. The analyses were adjusted for socio-demographic and lifestyle variables and for self-rated health (in the analysis with stress as the outcome variable) or stress (in the analysis with self-rated health as the outcome variable).

To examine if the likelihood of favourable stress and self-rated health outcomes increases with the number of movement guidelines met, we ran additional regression models. In these models, the explanatory variable was an ordered factor denoting the number of movement guidelines met (i.e. none, one, two, or all three). We tested for linear and quadratic trends between the explanatory variable (the number of movement guidelines met) and the outcome (stress frequency or self-rated health).

Proportional odds assumption and goodness of fit for each of the ordinal logistic regression models were assessed using the Brant test (63), Hosmer–Lemeshow test, Lipsitz test, and Pulkstenis–Robinson tests

(64).

Results

Sample characteristics

The mean ($\pm$ standard deviation) age of participants was 48 ± 14 years. Most participants were females and highly educated, had middle socio-economic status, and lived with their partner (Table 1). Approximately one third of participants (36%) reported experiencing stress often or every day and about two thirds of participants (68%) rated their health as good or very good. Only 25% of participants met all three guidelines, while 7% of participants did not meet any of the guidelines. Two guidelines were met by 41%, and a single guideline was met by 26% of participants.

Table 1
Participant characteristics

Characteristic	<i>n</i> (%)
Age groups	
18 to 44 years	896 (38)
45 to 64 years	1153 (49)
65 years or more	284 (12)
Female	1731 (74)
BMI	1220 (52)
Underweight or normal (< 25 kg/m ²)	
Overweight (25.0–29.9 kg/m ²)	811 (35)
Obese (≥ 30 kg/m ²)	302 (13)
Smoker	404 (17)
Education	
Primary or secondary education	687 (30)
Higher education	1646 (70)
Socio-economic status	
High or very high	277 (12)
Middle	1820 (78)
Low or very low	236 (10)
Living arrangement	
Living with partner	1785 (77)
Living without partner	548 (23)
Place of residence	
Urban	1219 (52)
Rural	1114 (48)
Self-rated health	
Very good	314 (13)

Note: BMI = body mass index; SB = sedentary behaviour; MVPA = moderate-to-vigorous physical activity

Characteristic	<i>n</i> (%)
Good	1287 (55)
Fair	658 (28)
Bad	68 (3)
Very bad	6 (0.3)
Experiencing stress	
Every day	139 (6)
Often	689 (30)
Occasionally	1086 (47)
Very rarely	392 (17)
Never	27 (1)
Meeting guidelines	
None	171 (7)
Only for MVPA	221 (9)
Only for SB	175 (8)
Only for sleep	217 (9)
For SB and MVPA	279 (12)
For sleep and MVPA	370 (16)
For sleep and SB	309 (13)
For sleep, SB, and MVPA	591 (25)
Number of guidelines met	
None	171 (7)
1	613 (26)
2	958 (41)
3	591 (25)
Note: BMI = body mass index; SB = sedentary behaviour; MVPA = moderate-to-vigorous physical activity	

Movement behaviours and stress

The regression model with stress frequency as the outcome variable did not violate the proportional odds assumption, and the goodness of fit was acceptable, as indicated by the Brant test ($\chi^2(69) = -86.68, p = > 0.999$), Lipsitz test ($LR(9) = 11.98, p = 0.214$), Hosmer–Lemeshow test ($\chi^2(35) = 32.54, p = 0.588$), and Pulkstenis–Robinson chi-square and deviance tests ($\chi^2(7289) = 7222, p = 0.709$; $D^2(7289) = 4272, p > 0.999$).

For the participants who only met the guideline for MVPA or for SB, we did not find a statistically significant difference from the reference group (i.e. those who did not meet any of the movement guidelines) in the frequency of stress (Table 2). Those who met the sleep guideline only had approximately two times greater odds of reporting lower frequency of stress, compared with the reference group. Similar associations with lower frequency of stress were found for meeting any two of the guidelines and for meeting the overall, combined guidelines.

In the regression model with the *number* of guidelines met as an explanatory variable, we found a significant linear trend. The likelihood of higher stress frequency decreased with the number of guidelines met.

Table 2

The association between meeting movement guidelines and the frequency of experiencing stress

	Odds Ratio [95% CI]	<i>p</i>
Guideline(s) met		
None	[<i>ref</i>]	
Only for MVPA	0.90 [0.61, 1.32]	0.582
Only for SB	0.75 [0.50, 1.12]	0.162
Only for sleep	0.51 [0.35, 0.75]	0.001**
For SB and MVPA	0.63 [0.43, 0.90]	0.013*
For sleep and MVPA	0.57 [0.40, 0.81]	0.002**
For sleep and SB	0.48 [0.33, 0.69]	< 0.001***
For sleep, SB, and MVPA	0.45 [0.32, 0.63]	< 0.001***
Number of guidelines met		
0	[<i>ref</i>]	
1	0.69 [0.50, 0.96]	0.027
2	0.55 [0.40, 0.76]	< 0.001***
3	0.45 [0.32, 0.62]	< 0.001***
Linear trend		< 0.001***
Quadratic trend		0.428
Note: CI = confidence interval; SB = sedentary behaviour; MVPA = moderate-to-vigorous physical activity. The regression models were adjusted for age, sex, body mass index, level of education, socio-economic status, employment status, place of residence (urban / rural), living arrangement (with partner / without partner), and smoking status. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$		

Movement behaviours and self-rated health

The Brant test ($\chi^2(69) = 66.84, p = 0.551$), Lipsitz test ($LR(9) = 4.96, p = 0.838$), Hosmer–Lemeshow test ($\chi^2(35) = 14.59, p = 0.999$), and Pulkstenis–Robinson chi-square and deviance tests ($\chi^2(7505) = 7036, p > 0.999$; $D^2(7505) = 3592, p > 0.999$) indicated that the regression model with self-rated health quality as the outcome variable did not violate the proportional odds assumption and that the goodness of fit was acceptable.

For the participants who only met the guideline for SB or for sleep, or for both sleep and SB, we did not find a statistically significant difference from the reference group (i.e. those who did not meet any of the movement guidelines) in self-rated health (Table 3). Those who met the MVPA guideline only had

approximately two times greater odds of reporting better health, compared with the reference group. Similar associations with better self-rated health were found for meeting any two of the guidelines, except sleep and SB. Those who met the overall, combined guidelines had approximately three times greater odds of reporting better health, compared with the reference group.

In the regression model with the *number* of guidelines met as an explanatory variable, we found a significant linear trend. The likelihood of better self-rated health increased with the number of guidelines met.

Table 3
The association between meeting movement guidelines and self-rated health

	Odds Ratio [95% CI]	<i>p</i>
Guideline(s) met		
None	[<i>ref</i>]	
Only for MVPA	2.24 [1.50, 3.36]	< 0.001***
Only for SB	1.43 [0.94, 2.19]	0.099
Only for sleep	1.02 [0.68, 1.53]	0.919
For SB and MVPA	2.33 [1.57, 3.44]	< 0.001***
For sleep and MVPA	1.78 [1.23, 2.59]	0.002**
For sleep and SB	1.37 [0.94, 2.00]	0.100
For sleep, SB, and MVPA	2.94 [2.07, 4.19]	< 0.001***
Number of guidelines met		
0	[<i>ref</i>]	
1	1.49 [1.06, 2.10]	0.022*
2	1.76 [1.26, 2.45]	0.001**
3	2.92 [2.05, 4.15]	< 0.001***
Linear trend		< 0.001***
Quadratic trend		0.599
Note: CI = confidence interval; SB = sedentary behaviour; MVPA = moderate-to-vigorous physical activity; BMI = body mass index. The regression models were adjusted for age, sex, body mass index, level of education, socio-economic status, employment status, place of residence (urban / rural), living arrangement (with partner / without partner), and smoking status. * <i>p</i> < 0.05, ** <i>p</i> < 0.01, *** <i>p</i> < 0.001		

Discussion

Main findings

The results of this study suggest that meeting the sleep guideline only, any combination of two movement behaviour guidelines, or all three movement behaviour guidelines is associated with less frequent stress. Meeting the MVPA guideline alone or in combination with any other movement behaviour guideline is associated with better self-rated health. We did not find significant associations with stress frequency and self-rated health for meeting the SB guideline only. The likelihood of less frequent stress and better self-rated health increases with the number of guidelines met. These findings stress the importance of encouraging adults to meet as many movement guidelines as possible.

Comparison with previous studies

Our findings are in accordance with the results of two studies conducted by Oftedal et al. (44, 45), in which the latent class representing a favourable movement behaviour composition (i.e. high MVPA, low SB, and sufficient sleep) was associated with the lowest likelihood of mental distress, compared with the remaining latent classes that represented unfavourable movement behaviour compositions. These comparisons should, however, be taken with caution, because the latent classes in the Oftedal et al. (44, 45) studies were based not only on movement behaviours but also on dietary habits. Furthermore, two other previous studies (46, 47) did not find a significant association between movement behaviours and stress, possibly because of their significantly smaller sample sizes compared to the current study. In our study, the strength of the association with stress frequency was almost identical across the groups meeting a combination of any two guidelines. It might be that for coping with stress the number of movement behaviour guidelines met matters more than which specific combination of movement guidelines is met.

Within the composition of movement behaviours, MVPA often shows the strongest positive association with mental well-being (65–68). However, we did not find a significant association between meeting the MVPA guideline and stress frequency. Leisure-time MVPA is often promoted as a strategy to manage stress (69, 70). It might be that some individuals in our sample met the MVPA guideline in the attempt to cope with frequent stress. Such cases could have attenuated the inverse association between MVPA and stress frequency in our sample, but this has to be confirmed in future, longitudinal studies.

Our findings regarding self-rated health are in accordance with the results of Oftedal et al. (44) study, in which all three latent classes representing unfavourable movement behaviour compositions had significantly worse self-rated health than the latent class representing a favourable composition of movement behaviours. In the Oftedal et al. (44) study, the poorest self-rated health status was found among those with a combination of low PA, high SB, and inadequate sleep, which is also congruent with the results of our study. As mentioned earlier, these comparisons should be taken with caution, because the latent classes in the Oftedal et al. (44) study were based not only on movement behaviours but also on dietary habits.

Our study showed that meeting the MVPA guideline alone or in a combination with meeting any other movement guideline is associated with better self-rated health, which is in accordance with previous findings. The positive association of MVPA with self-rated health among adults (while considering other movement behaviours) was also found in the von Rosen and Hagströmer (48) study. Similarly, results of the Park et al. (47) study suggested that increasing the time spent in MVPA at the expense of the time spent in SB is associated with better self-rated health in adults. Within the composition of movement behaviours, MVPA often shows the strongest positive association with health (1, 7, 42, 65). The findings in our sample seem to be in line with these findings.

Similar as in our sample of adults, meeting more movement behaviour guidelines was found to be associated with better health and well-being among Australian adolescents (71). These findings have important implications for health promotion, as they highlight the importance of encouraging adults to meet as many movement behaviour guidelines as possible. Promoting the integrated 24-hour movement guidelines might be a feasible way to do it (12, 16–18).

Strengths and limitations

The key strengths of the current study include a large sample size and exploring how meeting recommendations for specific movement behaviours (and all their combinations) is associated with two important health outcomes. Several limitations of the study should also be highlighted. First, the study sample was not representative of the general population, which limits the generalisability of the findings. Second, given that the data were collected using self-reports, the findings of the study may have been affected by recall errors and social desirability bias. Third, we did not consider guidelines on screen time and muscle-strengthening activity (12). Finally, no conclusions about causality could be drawn, because the study was cross-sectional. Studies with longitudinal and experimental designs are warranted to better understand the causal relationships.

Conclusion

Our results suggest that adults who meet the sleep guideline, any combination of two movement behaviour guidelines, or all three movement behaviour guidelines experience stress less frequently, compared with those who do not meet any of the guidelines. Meeting the MVPA guideline alone or in combination with any other movement behaviour guideline is associated with better self-rated health. The likelihood of less frequent stress and better self-rated health increases with the number of guidelines met. These findings highlight the public health importance of encouraging adults to meet as many movement behaviour guidelines as possible.

List Of Abbreviations

BMI, body mass index; CI, confidence interval; DABQ, Daily Activity Behaviours Questionnaire; MVPA, moderate-to-vigorous physical activity; OR, odds ratio; SB, sedentary behaviour; VIRTUE, Viable Integrative Research in Time-Use Epidemiology

Declarations

Ethics approval and consent to participate.

The study protocol was approved by the National Medical Ethics Committee (approval number: 0120-557/2017/4). All participants provided informed consent before commencing with the study.

Consent for publication.

Not applicable.

Availability of data and materials.

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests.

The authors declare that they have no competing interests.

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Authors' contributions.

KK and NŠ conceptualised the study. KK processed the data. KK and NK drafted the initial version of the manuscript. DL conceptualised and carried out statistical analysis, contributed to interpretation of results, and drafting the manuscript. ZP contributed to conceptualising the data analysis, interpretation of results, and drafting the manuscript. SC contributed to drafting the manuscript. All authors reviewed all versions of the manuscript and contributed intellectually to its content.

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