Health Related Quality of Life in Adolescents: Individual and Combined impact of health-related behaviors (DADOS Study)

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Declarations

Funding. The DADOS Study is funded by the Spanish Ministry of Economy and Competitiveness, MINECO (DEP2013–45515-R) and by the Jaume I University of Castellon, UJI (P1-1A2015-05 and UJI-A2019-12).

Conflicts of interest. The authors declare that they have no conflict of interest.

Ethics approval. This study was performed in line with the ethical guidelines of the Declaration of Helsinki 1964 (last revision of Fortaleza, Brazil, 2013) and approved by the Research Ethics Committee of the University Jaume I of Castellon (Spain).

Consent to participate. Adolescents and their parents or guardians were informed of the nature and characteristics of the study, and all provided a written informed consent.

Consent for publication. No applicable.

Availability of the data and material. No applicable.

Code availability. No applicable.

Author's contribution. All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Alba Solera-Sanchez, Mireia Adelantado-Renau, Diego Moliner-Urdiales and Maria Reyes Beltran-Valls. The first draft of the manuscript was written by Alba Solera-Sanchez and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

ABSTRACT

Purpose. To investigate the individual and combined effect of physical activity, adherence to the Mediterranean diet, sleep quality, sleep duration and screen time on health-related quality of life (HRQoL) in adolescents.

Methods. This is a cross-sectional analysis with 262 adolescents (13.9 ± 0.3 years) from DADOS (Deporte, ADOlescencia y Salud) study. Physical activity was assessed with a wrist-worn GENEActiv triaxial accelerometer. Adherence to the Mediterranean diet was evaluated by the KIDMED questionnaire. Sleep patterns were self-reported through the Spanish version of Pittsburgh Sleep Quality Index questionnaire. Screen time was assessed through the HELENA sedentary behavior questionnaire. HRQoL was measured using the KIDSCREEN-10 questionnaire. Scores were categorized into low and high using a normative cut-off used to identify factors associated with being in a high HRQoL group. A healthy lifestyle index was created including positive scores for each individual behavior, and five categories of achievement were stablished (0, 1, 2, 3, ≥4).

Results. Sleep patterns and screen time revealed a significant individual relationship with HRQoL ($p<0.05$). Adolescents achieving ≥3 positive health-related behaviors showed higher HRQoL levels compared to those fulfilling none ($p<0.05$). Logistic regression analysis revealed an increased likelihood of high HRQoL according to the number of positive health-related behaviors achieved ($p<0.05$).

Conclusions. Our results reveal higher levels of HRQoL in those adolescents achieving ≥3 health-related behaviors compared to their peers achieving none. Moreover, our findings show a cumulative effect of health-related behaviors on HRQoL. These findings underline the key role of promoting a healthy lifestyle in order to improve adolescent's health and well-being.

Key words: Adolescence, diet, sleep, physical activity, screen time.

INTRODUCTION

Health-related quality of life (HRQoL) could be defined as individuals' functioning performance in life and their perceived well-being in physical, mental and social domains of health [1]. Since perceived health and functionality are considered important components of health surveillance, HRQoL has been suggested as an important health indicator [2]. Thus, identifying the elements that could contribute to improve HRQoL should be a health priority nowadays.

Prior research has shown that HRQoL is closely linked to health-related behaviors in adolescents [3–7]. For instance, high levels of physical activity were associated with greater HRQoL in children and adolescents [8]. Regarding healthy dietary patterns, adherence to the Mediterranean diet was positively associated with HRQoL [3]. In addition, prior scientific evidence has suggested that adolescents with poor sleep quality [4, 7] and short sleep duration [6] showed lower HRQoL. Screen time was also negatively associated with HRQoL in children and adolescents [5].

Although youth adherence to single health-related behaviors seems to significantly contribute to HRQoL [3–7], adolescents tend to adhere to a number of health-related behaviors simultaneously [9], which may increase each single health-related behavior effect. Indeed, previous research suggested that the adherence to multiple health-related behaviors simultaneously may improve their respective individual impact on health by synergistically interacting with each other [10]. Studies performed on different populations have reported an association between the number of health-related behaviors adhered and indicators such as weight status, physical functioning, or mortality [11–13]. However, to the best of our knowledge, only one study has investigated the combined effect of these behaviors on HRQoL in this age population [14] reporting a positive relationship between a healthy lifestyle composite score and HRQoL. Yet, as recognized by Marques et al. [14] reliability and validity of the lifestyle behaviors measured was not considered.

Therefore, it would be interesting to expand the scarce knowledge in adolescents about the effect of adhering to several modifiable lifestyle factors on HRQoL, including valid measuring instruments and quantifying the magnitude of the effect. This understanding would help to design effective public health policies and would be informative for allocating prevention resources. Thus, the aim of the present study was to investigate the individual and combined effect of several health-related behaviors (i.e., physical

activity, adherence to the Mediterranean diet, sleep quality, sleep duration, and screen time) on HRQoL in adolescents.

METHODS

Study design and sample selection

This study is part of the DADOS (Deporte, ADOlescencia y Salud) research project, a 3-year longitudinal study aimed to analyze the influence of lifestyle behaviors on health and academic performance in adolescents. The results presented in this study belong to baseline data obtained between February and May of 2015. A convenience sampling technique was used to recruit participants. For that purpose, advertising leaflets about the research project were sent to secondary schools and sport clubs located in the province of Castellon (Spain) which included basic information and the general inclusion criteria of DADOS study. The inclusion criteria were to be enrolled in second grade of secondary school, and to be free of physical (i.e. locomotor system) and cognitive (i.e. intellectual ability) impairments. Volunteers who declared to meet these criteria were included in the study. A total of 262 adolescents aged 13.9 ± 0.3 years (48% girls) completed the baseline assessment with valid data for vigorous physical activity, adherence to the Mediterranean diet, sleep quality, sleep duration, screen time, and HRQoL.

Adolescents and their parents or guardians were informed about the nature and characteristics of the study, and all provided a written informed consent. The DADOS study protocol was designed in accordance with the ethical guidelines of the Declaration of Helsinki 1964 (last revision of Fortaleza, Brazil, 2013) and approved by the Research Ethics Committee of the University Jaume I of Castellon (Spain).

Health-related behaviors

Physical Activity

Levels of physical activity were objectively measured using the GENEActiv accelerometer (Activinsights Ltd, Kimbolton, Cambridgeshire, UK), a waterproof device which contains a triaxial microelectromechanical accelerometer that records both motion-related and gravitational acceleration, and has a linear and equal sensitivity along the three axes. Participants wore the accelerometer on their non-dominant wrist. GENEActiv accelerometer offers a body temperature sensor to detect wear and non-wear time. Accelerometer-derived data from all participants comprised at least four complete days, including weekend and weekdays, with 24h valid data. This device provides a reliable (coefficient of variation intra-

and inter-instrument of 1.4% and 2.1%, respectively) [15] and valid assessment of physical activity in young people ($r = 0.925$, $p = 0.001$) [16]. Accelerometers were programmed to collect data at a sampling frequency of 100 Hz and stored in gravity (g) units. The raw acceleration output was added in 1-s epochs using the GENEActiv postprocessing PC software (version 2.2; GENEActiv). By combining all registered days for each participant and using the Excel macro provided by the commercial brand to summarize the data, physical activity was expressed as average minutes per day of vigorous physical activity. According to Phillips et al. [16], GENEActiv cutoff point for vigorous intensity in children/adolescents was established for values over 60g. In the current study, vigorous physical activity was chosen to be included in the analyses due to its stronger relationship with health parameters than moderate or light intensities [17, 18]. Participants above the sex-specific 75th percentile were categorized as high vigorous physical activity.

Adherence to the Mediterranean Dietary Patterns

Adherence to the Mediterranean diet was assessed using the KIDMED [19], a questionnaire based on the Mediterranean dietary guidelines for children and adolescents which provides an overall indication of the adequacy to its dietary patterns. The KIDMED includes 16 yes/no questions, 12 with a positive connotation and 4 with a negative one with respect to dietary patterns quality. Questions with a positive connotation with respect to a high-quality diet were assigned a value of +1 (e.g., daily fruit and vegetables consumption, weekly fish and legumes intake), while those with a negative connotation were assigned a value of −1 (e.g., subjects' consumption of fast food, sweets and soft drinks). The final score for the participants' adherence to the Mediterranean dietary pattern was calculated as the sum of each answer, which ranges from zero to 12. According to the KIDMED questionnaire instructions [19], levels of adherence are classified into: (1) ≥8 points: optimal adequacy to the Mediterranean dietary patterns; (2) 4-7 points: improvement needed to adjust intake to Mediterranean patterns; (3) ≤3 points: very poor diet quality according to Mediterranean guidelines. For the purposes of the current study, the scores were organized into two groups: poor (0–7) vs. optimal (8–12).

Sleep quality

Sleep quality was assessed through the Spanish version of the Pittsburgh Sleep Quality Index (PSQI) questionnaire [20]. Good psychometric properties have been established in adults in both clinical and nonclinical settings [19, 21, 22]. In addition, previous data from adolescents' population also showed that the PSQI has adequate reliability (Cronbach's $\alpha = 0.72$), good test–retest stability over a 6-week period (r

146 = 0.81, p <0.001), and good divergent (r = −0.35) and convergent (r = 0.42) validity with positive mood
147 and fatigue, respectively [23]. Similar reliability results have been obtained in the current sample
148 (Cronbach's α = 0.70). It includes 19 questions that assess 7 components of sleep quality: subjective sleep
149 quality, sleep duration, sleep latency, habitual sleep efficiency, sleep disturbance, use of sleep medication,
150 and daytime dysfunction. Each component score is rated on a 3-point ascending scale, with 0 points
151 indicating ideal sleep quality and 3 points indicating poor sleep quality. The global score of the PSQI was
152 used in the analysis as the addition of all component scores, ranging from 0 to 21, with lower scores
153 representing better sleep quality. According to Buysse et al. the PSQI questionnaire provides a sensitive
154 measure to identify good sleep quality if total PSQI score is ≤5 [21].

155 **Sleep duration**

156 Subjective information on sleep duration was estimated from the PSQI questionnaire [20] through the
157 following questions: "during the past month, when have you usually gone to bed at night?" and "during the
158 past month, when have you usually gotten up in the morning?" Sleep duration was calculated as the
159 difference between bedtime and time for getting up. According to the definition of the National Sleep
160 Foundation for adolescent populations, good sleep duration was defined as ≥8 h per day [24].

161 **Screen time**

162 Screen time was assessed using the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence)
163 sedentary questionnaire [25]. For both, weekend and weekdays, adolescents reported the number of hours
164 spent on television, videogames, internet and mobile phone. Seven possible answers were available for each
165 item: no time, <30 min, ≥30 to <60 min, ≥1 to <2 h, ≥2 to <3 h, ≥3 to <4 h, and ≥4 h. Total screen time for
166 weekend and weekdays was calculated adding the mean time of each screen-based activity. The overall
167 time was established as follows: 1/7 × (2 × weekend days + 5 × weekdays), and participants under the sex-
168 specific 25th percentile were categorized as low screen time.

169 **Healthy lifestyle index**

170 A healthy lifestyle index ranging from a score of 0 to 5 was specifically defined for our sample according
171 to the number of health-related behaviors accomplished by each adolescent: (1) high vigorous physical

activity; (2) optimal adherence to the Mediterranean diet; (3) good sleep quality; (4) good sleep duration, and (5) low screen time. Thus, a higher score indicates a healthier lifestyle.

Health Related Quality of Life

HRQoL was assessed with the KIDSCREEN-10 questionnaire, a valid and reliably scale to analyze HRQoL among youth population [26]. The reliability and validity of the questionnaire has been examined previously in adolescents showing good reliability (Cronbach's $\alpha = 0.82$) and criterion validity ($r = 0.91$) [26]. Optimal reliability results have also been obtained in the current study (Cronbach's $\alpha = 0.77$). This questionnaire consists of a 10-item scale to assess vitality and energy, symptoms of depressed mood, youth's opportunities to structure his/her leisure time and enjoying social activities, and youth's perception of his/her cognitive capacity and satisfaction with school performance. Each item is rated in a 5-point Likert scale (i.e., 1 = "nothing" and 5 = "very much"). Responses were coded so that higher values indicate better HRQoL. Then, the sum of the items was calculated, and it was transformed based on the RASCH-Person parameters estimates [2]. A higher score in the questionnaire indicate better HRQoL. Participants above the sex- specific mean normative value from European adolescents [2], which stablishes the threshold on 49.00 mean value for females and 51.12 mean value for males, were classified as having high HRQoL.

Covariates

Sex, pubertal stage, socioeconomic status, waist circumference, and parents' education level were included as covariates in the statistical analyses [27, 28].

Pubertal stage

Pubertal stage was self-reported according to the five stages described by Tanner and Whitehouse [29]. It is based on external primary and secondary sexual characteristics, which are described by the participants using standard pictures according to Tanner instructions. Self-assessment can be validly used in epidemiologic studies for evaluation of sexual maturation [30].

Socioeconomic status

The Family Affluence Scale (FAS) developed by Currie et al. was used as a proxy of socioeconomic status (ranging from 0 to 8), which is based on material conditions in the family such as car ownership, bedroom occupancy, computer ownership, and home internet access [31].

Waist circumference

Waist circumference was measured twice to the nearest 1 mm with a non-elastic tape applied horizontally midway between the lowest rib margin and the iliac crest, at the end of gentle expiration with the adolescent in a standing position. The average measure was used for the analyses.

Parent's education level

Parents or legal guardians reported their education level which was categorized into two groups using the highest education level obtained by the mother or the father: (i) below university education, and (ii) university education.

Statistical analysis

Study sample characteristics are presented as mean ± standard deviation and percentages for continuous and categorical variables, respectively. Sex differences were assessed using independent *t*-test for continuous variables, and chi-square test for nominal variables. All variables were checked for normality using both graphical (normal probability plots) and statistical (Kolmogorov–Smirnov test) procedures. As preliminary analyses did not show a significant interaction of sex with the health-related behaviors variables in relation to HRQoL (all $p > 0.10$), all analyses were performed with the total sample.

Differences in HRQoL between health-related behaviors categories individually were analyzed by one-way analysis of covariance (ANCOVA). Linear regression analyses were conducted to examine the associations between individual health-related behaviors and HRQoL. Moreover, ANCOVA analyses, with a Bonferroni *post hoc* test, was performed to investigate HRQoL differences based on the number of health-related behaviors accomplished by adolescents (i.e., healthy lifestyle index). Partial eta-squared (η^2_p) where calculated to evaluate the effect size with following interpretation: <0.01 = trivial; 0.01–0.06 = small; 0.06–0.14 = medium; and >0.14 = large [32]. Additionally, logistic regression was conducted to examine the likelihood of having high HRQoL based on the number of health-related behaviors achieved (i.e., healthy

lifestyle index). For these analyses, the following categories of the healthy lifestyle index (independent variable) were used: 0, 1, 2, 3 and ≥4. The analyses were adjusted for sex, pubertal stage, socioeconomic status, waist circumference, and parents' education level and were performed using the IBM SPSS Statistics for Windows version 22.0 (Armonk, NY: IBM Corp). A *p*-value of < 0.05 was set as statistically significant.

RESULTS

Descriptive characteristics of the study sample are presented by sex in **Table 1**. Overall, compared to boys, girls showed lower levels of daily vigorous physical activity, poorer adherence to the Mediterranean diet, poorer sleep quality, and shorter sleep duration (all $p<0.05$). Regarding HRQoL, boys scored greater than girls ($p<0.05$).

Table 2 shows associations between health-related behaviors individually and HRQoL, adjusted for sex, pubertal stage, socioeconomic status, waist circumference, and parent's education level. Linear regression analyses indicated that adherence to the Mediterranean diet ($p<0.05$), sleep quality, and sleep duration ($p<0.001$) were individually associated with adolescents HRQoL. However, vigorous physical activity ($p=0.703$) and screen time ($p=0.072$) showed no individual associations.

Figure 1 shows HRQoL differences between categories of health-related behaviors individually, adjusted for sex, pubertal stage, socioeconomic status, waist circumference, and parent's education level. Adolescents with good sleep quality (PSQI scores ≤5) reported higher HRQoL than their peers with poor sleep quality (50.9 ± 0.6 vs. 48.5 ± 0.8, $p=0.016$). Regarding sleep duration, participants with good sleep duration (≥8 h per day) showed a higher HRQoL than those with poor sleep duration (51.2 ± 0.6 vs. 47.4 ± 0.9, $p<0.001$). Moreover, participants with low screen time (sex-specific <25th percentile) showed greater HRQoL than those with high screen time (52.1 ± 0.9 vs. 49.3 ± 0.6, $p=0.010$).

The differences in HRQoL according to the healthy lifestyle index are presented in **Figure 2**. The analyses showed significant differences in HRQoL between healthy lifestyle index categories ($F_{(4,260)}=5.17$, $p=0.001$; $\eta^2_p=0.08$), after adjusting for sex, pubertal stage, socioeconomic status, waist circumference, and parents' education level. Specifically, adolescents with a healthy lifestyle index of 3 or ≥4 had higher HRQoL than those with a healthy lifestyle index of 0 (52.2 ± 0.9 and 52.5 ± 1.1, respectively, vs. 45.7 ± 1.7; all $p=0.01$).

Table 3 shows the results of the healthy lifestyle index predicting high HRQoL in adolescents. Logistic regression analyses in the unadjusted model (model 1) indicated that adolescents with a healthy lifestyle

index of 1 (OR: 4.07 [95% CI: 1.37-12.14]), 2 (OR: 5.41 [95% CI: 1.89-15.54]), 3 (OR: 5.81 [95% CI: 1.97-17.07]) or ≥4 (OR: 6.64 [95% CI: 2.01-21.09]) were more likely to achieve greater HRQoL than their peers with 0. When the analyses were adjusted for sex, pubertal stage, socioeconomic status, waist circumference, and parents' education level (model 2), adolescents with a healthy lifestyle index of 2 (OR: 4.17 [95% CI: 1.37-12.73]), 3 (OR: 3.96 [95% CI: 1.28-12.28]) and ≥4 (OR: 4.63 [95% CI: 1.32-16.25]) showed greater odds of having high HRQoL, compared to their peers with a healthy lifestyle index of 0.

DISCUSSION

The main finding of the present cross-sectional research reveals that a combination of health-related behaviors, including high vigorous physical activity, optimal adherence to the Mediterranean diet, good sleep quality, good sleep duration, and low screen time, was associated with higher HRQoL in adolescents. Additionally, the more health-related behaviors accomplished, the more likelihood of having high HRQoL. Our results extend the scarce current scientific literature by suggesting that the combination of several health-related behaviors has a stronger impact on HRQoL than their respective individual effects.

We found a significant association between sleep quality and duration with HRQoL, indicating that better and longer sleep were associated with higher HRQoL. In addition, good sleepers reported significantly higher HRQoL than poor sleepers. This study supports prior research by confirming the individual positive influence of sleep quality and sleep duration on HRQoL [4, 7, 36]. Our results might be partially explained by the direct consequence that both poor or insufficient sleep have on increased daytime sleepiness [35]. Increased daytime sleepiness may lead to reduced alertness and compromise daytime functioning, including fatigue, mood changes, performance decrements, memory difficulties, and difficulties in coping with daily life [36]. Thus, daytime impairments resulting from reduced sleep quality and duration influence cognitive, physical, and emotional performance throughout the day, which may in turn impact HRQoL in adolescents [37, 38].

In line with previous scientific literature, our results showed that adolescents with low screen time (i.e., use of media devices such as television, phone and videogames) had higher HRQoL [5]. However, we did not find a significant association between total screen time and HRQoL in our sample. Our findings could be related to the passivity and solitary characteristics of screen activities, which may replace social activities and do not imply situations that require problem solving, cognitive or physical challenges [39, 40]. These

characteristics could influence life satisfaction, psychological well-being, or physical health status, which in turn may influence HRQoL [41].

Our study agrees with previous research which also showed that adherence to the Mediterranean diet was positively associated with HRQoL [3]. However, we did not find significant differences between adolescents with optimal and poor adherence to this dietary pattern. A possible explanation of this association is that Mediterranean dietary patterns includes food rich in nutrients such as antioxidants, fiber, minerals, vitamins, omega-3 fatty acids (from fish) and monounsaturated fatty acids that have shown a protective role for physical and mental health status [42], so we could hypothesize that it may translate in better HRQoL.

Vigorous physical activity was not independently related with HRQoL in our study. Nevertheless, previous research in adolescents has reported a positive association between physical activity and HRQoL [3, 8]. Vigorous physical activity has been related to less risk of suffering depressive symptoms [17], better cardiometabolic status [18] and sleep restoring and psychological functioning [44] in adolescents, which could influence HRQoL. Thus, although we did not find an individual association between vigorous physical activity levels and HRQoL, it is likely that combined with the other health-related behaviors investigated, it may also impact HRQoL [45]. Hence, based on prior evidence, these health-related behaviors were included in the healthy lifestyle index to examine the combined relationship with HRQoL.

The combined effect analysis revealed that adolescents with a healthy lifestyle index of 3 or ≥4 compared with those with an index of 0, showed greater mean score values for HRQoL with a moderate effect as denoted by the medium effect size obtained. Additionally, a cumulative effect of the health-related behaviors on HRQoL was found in our sample. Although our results indicated that not all the health-related behaviors included on the current research have the same impact on adolescents' HRQoL, from a practical point of view, the combined effect analyses revealed that the more health-related behaviors achieved, the better HRQoL. To date, only one study has analyzed the combined influence of several health-related behaviors on HRQoL in adolescents [14]. The mentioned study included 6 health-related behaviors (i.e., physical activity, screen time, sleep duration, diet fruit and vegetable consumption, drinking alcohol, and smoking), and found that adolescents engaged in all the healthy behaviors showed significantly higher HRQoL. Our results agree with this previous research by confirming that adhering to several health-related behaviors is associated with higher levels of HRQoL. For the first time we revealed an increased likelihood

of high HRQoL as the number of health-related behaviors accomplished raised. These findings could be explained by the combination of all the positive effects that some health-related behaviors have on the HRQoL, which may exert a cumulative effect on adolescents' HRQoL. Yet, it is necessary to highlight that the regression analyses results showed large confidence intervals, indicating a low level of precision of the odds ratio predicting high HRQoL.

Our research combined five health-related behaviors in a healthy lifestyle index to provide a better comprehension of the influence of those behaviors on HRQoL in adolescent population. Given the cumulative effect of adopting several health-related behaviors [45], it would be interesting that public health strategies focus on the promotion of multi-behavioral health policies. This is especially relevant during adolescence, an important period of life in terms of establishment of health-related behaviors, which appear to track into later age-spans [46], influencing health during adulthood [9].

Strengths of the study included homogeneous age-matched sample of adolescents, the use of validated and standardized tests to assess adherence to the Mediterranean diet, sleep quality, sleep duration, and HRQoL, and the objective measure of physical activity by accelerometry. In addition, our results were adjusted by waist circumference and socioeconomic status [27, 28], which have been previously shown to affect the HRQoL. Limitations of our study includes the cross-sectional design, which not allow us to report causality. In addition, the sample size and the use of some subjective data could have influenced our results. It is also important to mention that health-related behaviors choices during adolescence are strongly determined by other factors such as family and school environments [47, 48], but these variables were not considered in our analyses, which could have influenced our findings. Additionally, dietary patterns of the participants could be influenced by family structure, traditions and parents' diet habits. However, these variables were not evaluated in our sample. Finally, although the sample enrolled auto-reported that were not diagnosed of any physical or mental illness, their current mental health was not taken into consideration in our analyses, which could have influenced the results.

In conclusion, the results of the current research show that sleep quality, sleep duration, and screen time have an individual positive relationship with HRQoL in adolescents. Furthermore, the combined effect of several health-related behaviors has a stronger influence on HRQoL. Our findings are important because of the key role of holding a high HRQoL throughout life. Educational and public health interventions and

prevention strategies directed towards adolescents should focus on developing multiple health-related throughout youth.

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Table 1. Descriptive characteristics of the study sample (N= 262).

	Girls (n=125)	Boys (n=137)	All	p value *
Age (years)	13.9 ± 0.3	13.9 ± 0.3	13.9 ± 0.3	0.956
Pubertal stage (II-V) (%)	6/35/54/5	10/32/44/14	8/34/49/9	-
Socioeconomic status (0-8)	4.4 ± 1.4	4.0 ± 1.3	4.2 ± 1.4	**0.032**
Waist Circumference (cm)	66.5 ± 6.0	68.1 ± 5.5	67.3 ± 5.8	**0.021**
Obese participants (%)	2.4	2.2	2.3	0.967
Parents with university level education (%)	54.0	42.6	48.1	0.066
Health-related behaviours				
Vigorous physical activity (min/day)	8.9 ± 7.6	15.6 ± 7.8	12.4 ± 8.3	**<0.001**
High vigorous physical activity (%)	24.8	24.8	24.8	0.997
Adherence to the Mediterranean Diet (0-12)	6.7 ± 2.2	7.3 ± 2.1	7.0 ± 2.2	**0.033**
Optimal adherence (%)	38.4	47.4	43.1	0.140
Sleep quality (0-21)	5.5 ± 2.7	4.2 ± 2.7	4.8 ± 2.8	**<0.001**
Good sleep quality (%)	53.6	73.7	64.1	**0.001**
Sleep duration (h/day)	8.1 ± 0.9	8.3 ± 0.7	8.2 ± 0.8	**0.008**
Good sleep duration (%)	59.2	77.4	68.7	**0.002**
Screen time (h/day)	5.0 ± 2.6	4.7 ± 2.5	4.8 ± 2.5	0.300
Low screen time (%)	28.8	24.8	26.7	0.467
Health-related quality of life (Minimum - maximum values)	47.5 ± 7.4 (31.93 - 83.81)	52.3 ± 7.8 (40.24 - 83.81)	50.0 ± 8.0 (31.93 - 83.81)	**<0.001**
High health-related quality of life (%)	68.8	87.6	78.6	**<0.001**

Data are presented as mean ± standard deviation, or percentages. Differences between sexes were examined by *t*-test or chi-square test. Statistically significant values are in bold. High vigorous physical activity was defined as the sex-specific ≥75th percentile. Good adherence to Mediterranean diet indicates a score ≥8. Good sleep quality indicates a Pittsburgh sleep quality index ≤5. Good sleep duration indicates ≥8 h per day. Low screen time was defined as the sex-specific ≤25th percentile. Health-related quality of life was assessed with the KIDSCREEN-10 questionnaire. High health-related quality of life indicates high level according to European normative values for adolescents.

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Table 2. Associations between health-related behaviors and health related quality of life (N= 262).

	Health-related quality of life		
	β	95% CI	*p*
Vigorous physical activity	0.026	0.024; 0.064	0.703
Adherence to the Mediterranean diet	0.163	0.606; 0.222	**0.007**
Sleep quality	-0.232	-0.664; 0.173	**<0.001**
Sleep duration	0.236	2.334; 0.583	**<0.001**
Screen time	-0.111	-0.006; 0.003	0.072

Data are presented as standardized regression coefficient (β) and 95% confidence interval (CI). Analyses were adjusted by sex, pubertal stage, socioeconomic status, waist circumference and parents' education level. Health related quality of life was measured using Kidscreen-10. Statistically significant values are in bold.

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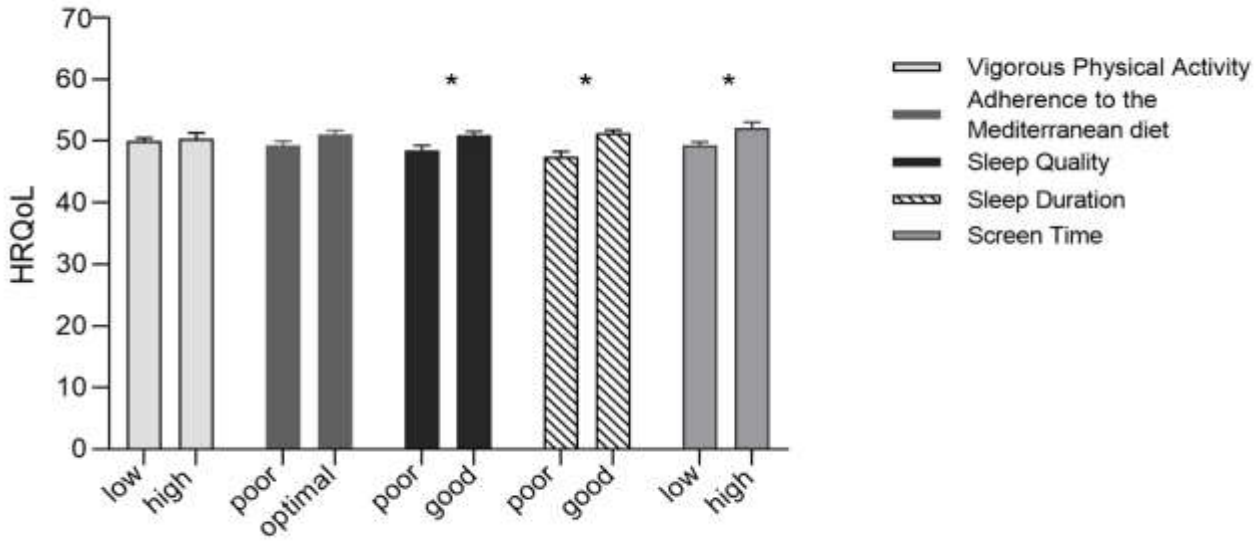

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496 **Fig.1** ANCOVA analysis examining individual effects of health-related behaviours on health-related quality of life in adolescents. Analyses were adjusted by
497 sex, pubertal stage, socioeconomic status, waist circumference and parents' education level. Estimated marginal means with their 95% Confidence Intervals are
498 depicted. HRQoL: Health-related quality of life. * indicates significant differences between groups ($p<0.05$).

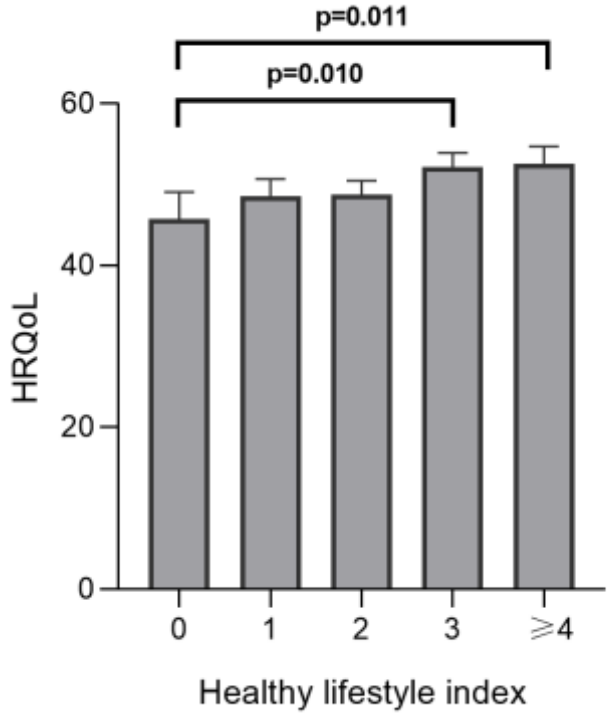

Fig.2 Differences in health-related quality of life according to the healthy lifestyle index, after adjusting for sex, pubertal stage, socioeconomic status, waist circumference and parents' education level. Estimated marginal means with their 95% Confidence Intervals are presented. HRQoL: Health-related quality of life. Adolescents with a healthy lifestyle index = 0 (n = 20), 1 (n = 51), 2 (n = 75), 3 (n = 69), and ≥4 (n = 45).

Table 3. Logistic regression analysis predicting high health-related quality of life according to the healthy lifestyle index (N = 262).

		High health-related quality of life			
Healthy lifestyle index		Model 1		Model 2	
	N	OR (95% CI)	*p*	OR (95% CI)	*p*
0	20	1 (ref.)	-	1 (ref.)	-
1	51	4.07 (1.37-12.14)	**0.012**	3.04 (0.97-9.54)	0.057
2	75	5.41 (1.89-15.54)	**0.002**	4.17 (1.37-12.73)	**0.012**
3	69	5.81 (1.97-17.07)	**0.001**	3.96 (1.28-12.28)	**0.017**
4	45	6.64 (2.01-21.90)	**0.002**	4.63 (1.32-16.25)	**0.017**

Model 1: Unadjusted odds ratio.

Model 2: Adjusted odds ratio. Analyses were adjusted by sex, pubertal stage, socioeconomic status, waist circumference and parents' education level. Health related quality of life scores were grouped into low and high, according to normative cut-offs: 49.00 mean value for females and 51.12 mean value for males. Odds ratio (95% Confidence Intervals) represents increased odds of achieving high health related quality of life. High vigorous physical activity, optimal adherence to the Mediterranean diet patterns, good sleep quality, good sleep duration, and low screen time were included in the healthy lifestyle index.

Statistically significant values are in bold. OR: odds ratio; CI: confidence intervals; N: number of participants in the group.

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