

Diet quality and academic performance in schoolchildren: the moderating role of weight status

Calidad de la dieta y rendimiento académico en escolares: el papel moderador del estado de peso

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Abstract

Background. There is currently a trend in the scientific literature that studies the association between dietary patterns and their impact on academic performance. **Aim.** To determine the predictive power of diet quality on academic performance in schoolchildren by observing the moderating role of weight status. **Methods.** A total of 244 schoolchildren (43.6% boys and 53.7% girls) from Spain (Tenerife), aged between 10 and 12 years ($M \pm SD$: 10.80 \pm 1.81 years) participated in this empirical descriptive and cross-sectional ex post facto study. Academic achievement was calculated through the grade obtained in the subjects of the primary school curriculum (Royal Decree 126/2014), the *KIDMED* questionnaire was used to quantify diet quality and nutritional status was assessed through the *Body Mass Index* (kg/m^2) adjusted for sex and age. **Results.** Higher diet quality correlates with higher scores in all academic subjects ($p < .05$) with the exception of Natural Sciences, Art Education, and Religion/Values and French ($p > .05$) with and without adjusting the model for normal weight. After adjusting the model for overweight, the significant relationship disappears in all subjects ($p > .05$), except for Mathematics and English ($p < .05$, for both). Likewise, the Johnson-Neyman test showed that there is no moderation of weight status in relation to diet quality and academic subjects ($p > .05$); with the exception of Physical Education ($p < .05$). **Conclusions.** Based on these results, further intervention and longitudinal research should be conducted to reveal possible strategies and policies that would improve school performance and overall health across the lifespan.

Keywords: Mediterranean diet, obesity, academic performance, nutritional education, childhood.

Resumen

Antecedentes. Actualmente existe una tendencia en la literatura científica que estudia la asociación entre los patrones dietéticos y su impacto en el rendimiento académico. **Objetivo.** Determinar el poder predictivo de la calidad de la dieta sobre el rendimiento académico en escolares observando el papel moderador del estado ponderal. **Métodos.** Un total de 244 escolares (43.6% niños y 53.7% niñas) de España (Tenerife), con edades comprendidas entre los 10 y los 12 años ($M \pm DE$: 10.80 ± 1.81 años) participaron en este estudio empírico descriptivo y transversal *ex post facto*. El rendimiento académico se calculó a través de la calificación obtenida en las asignaturas del currículo de primaria (Real Decreto 126/2014), se utilizó el cuestionario KIDMED para cuantificar la calidad de la dieta y se valoró el estado nutricional a través del Índice de Masa Corporal (kg/m^2) ajustado por sexo y edad. **Resultados.** Una mayor calidad de la dieta se correlaciona con mayores puntuaciones en todas las asignaturas académicas ($p < .05$) a excepción de Ciencias Naturales, Educación Artística y Religión/Valores y Francés ($p > .05$) con y sin ajustar el modelo por peso normal. Tras ajustar el modelo por sobrepeso, la relación significativa desaparece en todas las asignaturas ($p > .05$), excepto en Matemáticas e Inglés ($p < .05$, para ambas). Asimismo, la prueba de Johnson-Neyman mostró que no existe moderación del estado de peso en relación con la calidad de la dieta y las asignaturas académicas ($p > .05$); a excepción de Educación Física ($p < .05$). **Conclusiones.** En base a estos resultados, se deben realizar más intervenciones e investigaciones longitudinales para revelar posibles estrategias y políticas que mejoren el rendimiento escolar y la salud general a lo largo de la vida.

Palabras clave: Dieta mediterránea, obesidad, rendimiento académico, educación nutricional, infancia.

Introduction

From the heart to the earth through the path of culture, the Mediterranean diet is a cultural heritage recognised by UNESCO that looks towards a healthy future (Serra-Majem & Ortiz-Andrellucchi, 2018). However, the dietary profile of the school population is increasingly far from the quality of the optimal diet, mainly due to the low consumption of fruit,

vegetables, whole grains and the high consumption of meat and meat products, sweets and sugary drinks (García-Cantó et al., 2019). This variability in the quality of healthy and/or sustainable diets varies widely across the world and contexts (Carrillo-López et al., 2021a). In all of them, it has been described that this low diet quality can affect the survival, growth and proper development of schoolchildren by being associated with increased blood pressure and metabolic risk (Teixeira et al., 2021). In other words, energy-rich, nutrient-poor, ultra-processed foods are causing a global epidemic of disease (Kupka et al., 2020). Therefore, improving dietary habits towards optimal diet quality could be associated with better health from a holistic view (García-Hermoso et al., 2022).

Specifically, at the mental level, Kaliszewska et al. (2021) reveal a strong link between nutrition, mitochondrial functioning and cognition. In this sense, the integration of a healthy diet can provide optimal conditions for brain development and teach (Naveed et al., 2020). In this regard, there is currently an important scientific stream studying the association between dietary patterns and school academic performance. This literature has mainly focused on adolescents; presenting contradictory information on this relationship. That is, in 2016, a Europe-wide study pointed out that adherence to the Mediterranean diet may have a beneficial influence on academic performance (in four indicators: mathematics, language, mathematics and language average and grade point average). They highlighted that the benefits of adherence to the Mediterranean diet on academic performance may be stronger as young people adhere to optimal levels of the Mediterranean diet (Esteban-Cornejo et al., 2016).

A 2017 systematic review showed moderate associations for dietary intakes characterised by regular breakfast consumption, lower intake of energy-rich and nutrient-poor foods, and overall diet quality with respect to academic performance outcomes (Burrows et al., 2017). A three-year longitudinal study of high school students found that dietary habits were correlated with academic performance only in boys (Dubuc et al., 2020). Other research with high school students and standardised academic aptitude scores (Nawabjan & Nazni, 2021; Al-Saadi et al., 2020; Kristo et al., 2020) or global ratings of academic performance showed positive relationships with diet quality (Maniaci et al., 2021). In contrast, high academic performance has been found to be associated with a higher incidence rate of food addiction detection (Tserne et al., 2021).

Fewer studies have been found that analyse this relationship in primary school children. Among them, Qasrawi et al. (2021) found that healthy nutrition significantly predicts achievement scores. In both boys and girls, high academic performance was associated with high consumption of fruits and vegetables, low consumption of soft drinks, beverages (juices with sugar) and energy drinks, respectively. The high diet quality group scored higher in Arabic, English, mathematics, science and mean total score. Similarly, Faught et al. (2017) reported that poor diet quality was less likely to result in lower overall school performance. Similarly, optimal diet quality, such as not consuming cakes and sweet pastries, Chips, fried dumplings and pastries, was associated with differences in academic performance but only in mathematics (Gaete-Rivas et al., 2021). In contrast, another study found that a healthier diet was associated with better reading skills, but not with arithmetic skills (Haapala et al., 2017). However, another study found no significant relationship (Carrillo-López et al., 2021b). Similarly, Nakahara et al., (2020) did not observe a significant association between candy consumption and mathematics scores, however, higher candy consumption was significantly associated with higher Mongolian language scores.

Some studies have found that this association may be moderated by other factors. For example, in several studies after adjusting for gender, age or place of residence, the association was not significant (Mazandaranian et al., 2021; Barrios & Vernetta, 2021). Another possible moderator studied in secondary education has been weight status since it is obtained from the energy balance of nutrients ingested in the diet minus caloric expenditure and is measured by indicators such as body mass index for age and sex, an aspect that allows the diagnosis of weight status (Tapia-Serrano et al., 2021). In this study, they showed that language, mathematics and English scores were significantly associated with diet quality, independent of weight status. Despite the lack of significance, this study suggests that it seems likely that weight status might moderate the relationship between diet quality and academic performance. For this reason, they suggest further research and in primary school children. In this regard, this study is the first research to test the moderating role of weight status in the association between diet quality and academic performance in primary school children, and to examine how the relationship between diet quality and academic performance varies by weight status (normal weight vs. overweight). The choice of schoolchildren at this pre-adolescent stage is because this period is critical for neurodevelopment,

which is characterised by the establishment of behavioural patterns that can affect the physical, mental and academic health of schoolchildren, both immediately and later in life (Meli et al., 2022).

Based on these precedents, the predictive power of diet quality on academic performance in all subjects taken by primary school children is further explored by looking at the moderating role of weight status.

Method

Type of study and participants

Prior to conducting this research, the sample size was calculated in order to ensure robust results (Quispe et al., 2020). After jointly estimating the u (in reference to the number of variables) and f^2 (effect size in linear regression models) statistics, it was obtained that the minimum sample had to be a total of 217 subjects in order to carry out the linear regression technique, something that is fulfilled since we have a total sample of 244 students.

In this regard, a total of 244 schoolchildren (43.6% boys and 53.7% girls) from Spain (Tenerife), aged between 10 and 12 years ($M \pm SD$: 10.80 ± 1.81 years) participated in this empirical descriptive and cross-sectional ex post facto study. Sampling was non-probabilistic, non-random and convenience sampling (access to the sample). Four public schools were selected from rural (two schools) and urban (two schools) environments. These schools have a medium socio-economic level. In previous meetings held with the school principals and legal guardians of the schoolchildren, they were informed of the study protocol and informed consent was requested so that the schoolchildren could participate. Inclusion criteria were considered to be between 10-12 years of age and not to suffer from previous pathologies. In addition, the following exclusion criteria were considered: I) Failure to present informed consent to participate in the research, II) Attendance at more than 90% of academic classes.

Procedure and instruments

The work was carried out during the months of March and April of the 2019/2020 academic year. Each head of school and the representatives

of the parents' associations were informed of the purpose and protocol of the research at a meeting. The working team consisted of a principal researcher and four collaborating colleagues (teachers specialising in Primary Education and Physical Education). A theoretical session was held prior to the completion of the KIDMED questionnaire with each study group in order to ensure that all participants understood the questionnaires in this study. The research team administered the test in the natural groups of the PE class. All questionnaires were administered during the first school session in order to avoid the possible fatigue of the school day and to interrupt the school dynamics as little as possible.

The research was carried out in accordance with the ethical standards recognised by the Declaration of Helsinki (2013 revision), following the recommendations of Good Clinical Practice of the EEC (document 111/3976/88 of July 1990) and the current Spanish legal regulations governing clinical research on humans (Royal Decree 561/1993 on clinical trials).

Academic performance was considered as the dependent variable in this study. This was assessed by means of the grade obtained by fifth and sixth grade students in the first and second assessment carried out in the subjects of the Primary Education curriculum: Natural Sciences, Social Sciences, Spanish Language and Literature, Mathematics, First Foreign Language: English, Physical Education, Religion/Values and Second Foreign Language: French (Royal Decree 126/2014, of 28 February, establishing the basic curriculum of Primary Education and Decree 89/2014, of 1 August, establishing the organisation and curriculum of Primary Education in the Autonomous Community of the Canary Islands).

The values of all variables ranged from one to ten points. The score obtained in each subject derives from the total assessment of the learning established in the assessment criteria described in the Resolution of 13 May 2015 establishing the rubrics of the assessment criteria in Primary Education in the Autonomous Community of the Canary Islands, which emanate directly from Royal Decree 126/2014, of 28 February. These criteria are the fundamental reference for the assessment and marking of pupils throughout Spain.

The independent variables are:

I) Diet quality, quantified using the KIDMED questionnaire (Serra et al., 2004). This instrument is composed of 16 items that represent standards

of the traditional Mediterranean diet. Four of them are assessed with a negative score (-1 point) if answered positively (items 6, 12, 14 and 16), while the remaining twelve items are assessed with a positive score (+ 1) if answered positively. After summation, an overall score between -4 and 12 is obtained, which describes a better or worse quality of the diet. The value of the KIDMED index is: score ≤ 3 indicating a very low quality diet; score between 4 and 7 indicating the need to improve the dietary pattern to conform to the Mediterranean model; and finally, score ≥ 8 , showing an optimal Mediterranean diet. In order to obtain greater statistical power, participants were categorized into two groups: improvable DQ (≤ 7) and optimal DQ (≥ 8) as has been done in other previous studies (Carrillo-López, 2023; Tapia-Serrano et al., 2021).

II) Weight and height were determined using an electronic scale (TANITA TBF 300A, USA) and measuring rod (SECAA800, USA) with an accuracy of 100 g and 1 mm respectively, following the protocol of the International Society for the Advancement of Kynanthropometry with level I certified personnel. From these anthropometric variables, the body mass index (kg/m^2) was calculated. From this index, age- and sex-adjusted nutritional status was diagnosed (Cole & Lobstein, 2012). Participants were categorised into two groups: normal weight and overweight (overweight + obesity).

Statistical analysis

The normality and homogeneity of variances were obtained through the Kolmogorov Smirnov ($p > .212$) and Levene statistics ($p > .774$), respectively. As a normal distribution of the values recorded was observed, a parametric analysis was chosen. A differential analysis was then carried out. To indicate the characteristics of this sample, frequency distribution was used for categorical variables and descriptive analyses using the mean \pm standard deviation for continuous variables. Student's t-test was used to test for significant differences between groups and the chi-squared test for categorical variables. Subsequently, the PROCESS macro tool (version 3.5) of the SPSS software (IBM Corp, Armonk, New York, USA (version 23) was applied. This tool allows for moderation analysis (Hayes, 2017).

The initial analysis indicated no significant differences between the sexes; consequently, all analyses were conducted with males and females

together. This is to obtain greater statistical power. The moderation analysis was used to analyse whether diet quality (independent variable) was linked to academic performance (dependent variable) by looking at the moderating effect of weight status (moderator variable). Before interpreting the coefficients, goodness-of-fit and model assumptions were assessed. To analyse the goodness-of-fit, the F-test was used, which indicates whether the linear relationship being analysed is statistically significant. It should be noted that this statistic was significant, thus confirming the relevance of the regression technique (Martínez et al., 2020). With respect to the assumptions, as indicated by Pardo & San Martín (2010), the assumption of non-collinearity, linearity, independence of the errors and the Breusch-Pagan test to check the homogeneity of the residuals were checked, as well as the Breusch-Pagan test to check the homogeneity of the residuals. These assumptions are met in all models. The influence of outliers was also tested using Cook's distance. As the value obtained was less than 1, it was concluded that there was no influential case. An ordinary least squares (OLS) regression analysis was performed to predict the continuous variables (academic performance and KID-MED). In turn, since it is essential to determine the contribution of the predictor when carrying out a regression model, the R^2 statistic (Raschka & Mirjalili, 2019) was used (Raschka & Mirjalili, 2019). SPSS (version 23) was used for the analysis of all data. However, for the calculation of the sample size, the programme R, version 4.1.2 (pwr package) was used (Champely et al., 2018) with the significance level set at 5% ($p \leq .05$).

Results

Table I shows the scores obtained in the different variables of the study according to sex. It should be noted that no significant differences were obtained for any variable according to sex ($p > .05$).

In order to determine the predictive power of diet quality on academic performance in the core subjects by looking at the moderating role of weight status, a linear regression test was applied (see Table II). The crude model showed that higher values for diet quality correlated with higher values for academic performance in all subjects ($p < .05$) except Natural Science ($p > .05$). However, after the model was adjusted for Overweight, this relationship between diet quality and academic

TABLE I. Scores obtained in the different variables of the study according to sex

	Males M ± SD (n = 118)	Females M ± SD (n = 126)	F	p	d
Natural Sciences (1-10) ^a	5.69 ± 6.88	1.70 ± 1.40	4.132	.094	0.15
Social Sciences (1-10) ^a	6.07 ± 1.50	7.05 ± 1.57	1.050	.823	0.07
Spanish Language and Literature (1-10) ^a	5.76 ± 1.85	6.79 ± 1.69	1.793	.183	0.11
Mathematics (1-10) ^a	5.73 ± 1.99	6.48 ± 1.72	1.457	.230	0.10
English (1-10) ^a	5.61 ± 1.52	6.79 ± 1.45	1.591	.443	0.09
Art Education (1-10) ^a	5.87 ± 1.18	6.74 ± .97	1.928	.168	0.10
Physical Education (1-10) ^a	6.85 ± 1.30	7.09 ± 1.20	1.289	.592	0.07
Religion/ Values (1-10) ^a	6.30 ± 1.49	6.77 ± 1.57	1.041	.947	0.05
French (1-10) ^a	5.79 ± 1.28	6.90 ± 1.05	4.481	.064	0.15
Age (years)	10.44 ± 0.71	10.29 ± 0.84	1.619	.365	0.10
Height (cm)	154.01 ± 8.41	153.51 ± 8.28	1.570	.758	0.09
Weight (kg)	52.19 ± 13.25	48.11 ± 12.53	1.036	.218	0.12
BMI (kg/m ²) ^c	21.84 ± 4.22	22.28 ± 4.09	1.968	.044	0.16
Normal weight (n = 124) ^d	25%	25.9%	-	.389	-
Overweight ^d (n = 120)	27.6%	21.6%	-	.159	-
DQ ^e	7.53 ± 2.07	7.84 ± 2.62	2.935	.877	0.07
Improvable (n=108) ^d	25%	21.6%	-	.584	-
Optimal (n=136) ^d	27.6%	25.9%	-	.327	-

M ± SD = mean ± standard deviation. ^a Mean score obtained in the subject. ^c BMI = Body Mass Index. ^d Data presented as a cumulative percentage of the total sample. ^e Diet quality expressed from the mean score of the KIDMED scale.

Source: Compiled by author.

performance disappeared for all subjects ($p > .05$) except Mathematics and English ($p < .05$).

On the other hand, after observing the predictive power of diet quality on academic performance in the specific subjects of the curriculum by observing the moderating role of weight status (see Table III), significant values were obtained in the raw model only for the area of Physical Education ($p < .05$), but this relationship disappeared when the model was adjusted to overweight ($p > .05$).

TABLE II. Predictive value of diet quality on academic performance in core subjects

	Natural Sciences	Social Sciences	Spanish Language and Literature	Mathematics	English
Model I ^a	B = 0.084	B = 0.125	B = 0.173	B = 0.136	B = 0.140
	t = 1.258	t = 1.979	t = 2.392	t = 1.790	t = 3.439
	R ² = .014	R ² = .033	R ² = .048	R ² = .072	R ² = .041
	p = .211	p = .041*	p = .018*	p = .046*	p = .028*
Model II ^b	B = 0.089	B = 0.152	B = 0.194	B = 0.142	B = 0.142
	t = 1.411	t = 2.120	t = 2.451	t = 1.814	t = 3.514
	R ² = .016	R ² = .028	R ² = .051	R ² = .078	R ² = .051
	p = .192	p = .041*	p = .014*	p = .045*	p = .024*
Model III ^c	B = 0.044	B = 0.108	B = 0.148	B = 0.173	B = 0.173
	t = .439	t = 1.104	t = 1.311	t = 1.396	t = 1.622
	R ² = .003	R ² = .022	R ² = .030	R ² = .052	R ² = .056
	p = .663	p = .274	p = .195	p = .048*	p = .032*

Note. ^a Model I adjusted for age, gender and place of residence; ^b Model II adjusted for age, gender, place of residence and normal weight. ^c Model III adjusted for age, gender, place of residence and overweight.

Source: Compiled by author.

TABLE III. Predictive value of diet quality on academic performance in specific subjects

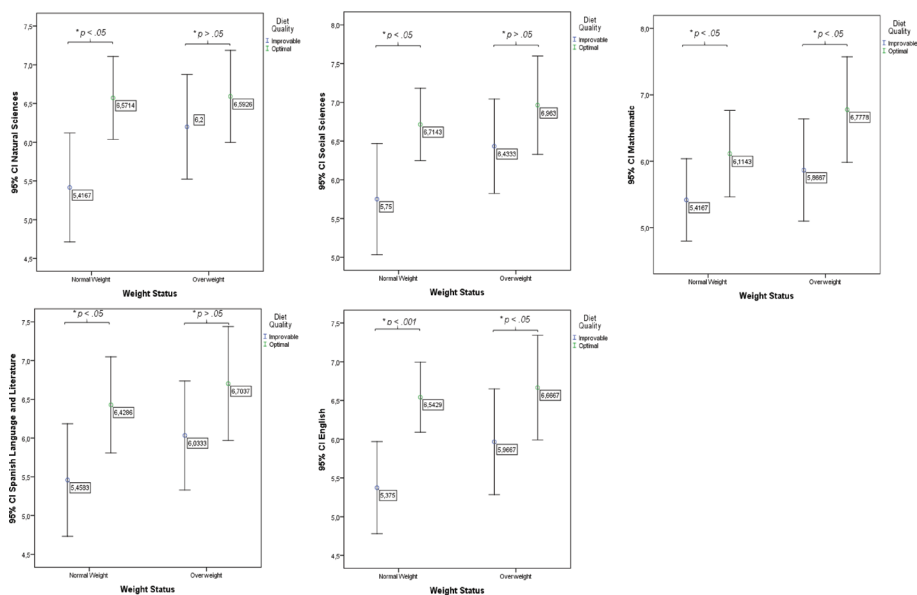
	Art Education	Physical Education	Religion/ Values	French
Model I ^a	B = 0.059	B = 0.127	B = 0.114	B = 0.037
	t = 1.749	t = 2.584	t = 1.877	t = 1.706
	R ² = .014	R ² = .055	R ² = .030	R ² = .004
	p = .206	p = .011*	p = .063	p = .482
Model II ^b	B = 0.62	B = 0.124	B = 0.154	B = 0.123
	t = 1.825	t = 2.874	t = 1.982	t = 1.888
	R ² = .014	R ² = .062	R ² = .032	R ² = .005
	p = .192	p = .004*	p = .056	p = .328
Model III ^c	B = 0.92	B = 0.111	B = 0.064	B = 0.038
	t = 1.221	t = 1.448	t = 1.645	t = 1.850
	R ² = .026	R ² = .037	R ² = .008	R ² = .003
	p = .227	p = .153	p = .522	p = .562

Note. ^a Model I adjusted for age, gender and place of residence; ^b Model II adjusted for age, gender, place of residence and normal weight. ^c Model III adjusted for age, gender, place of residence and overweight.

Source: Compiled by author.

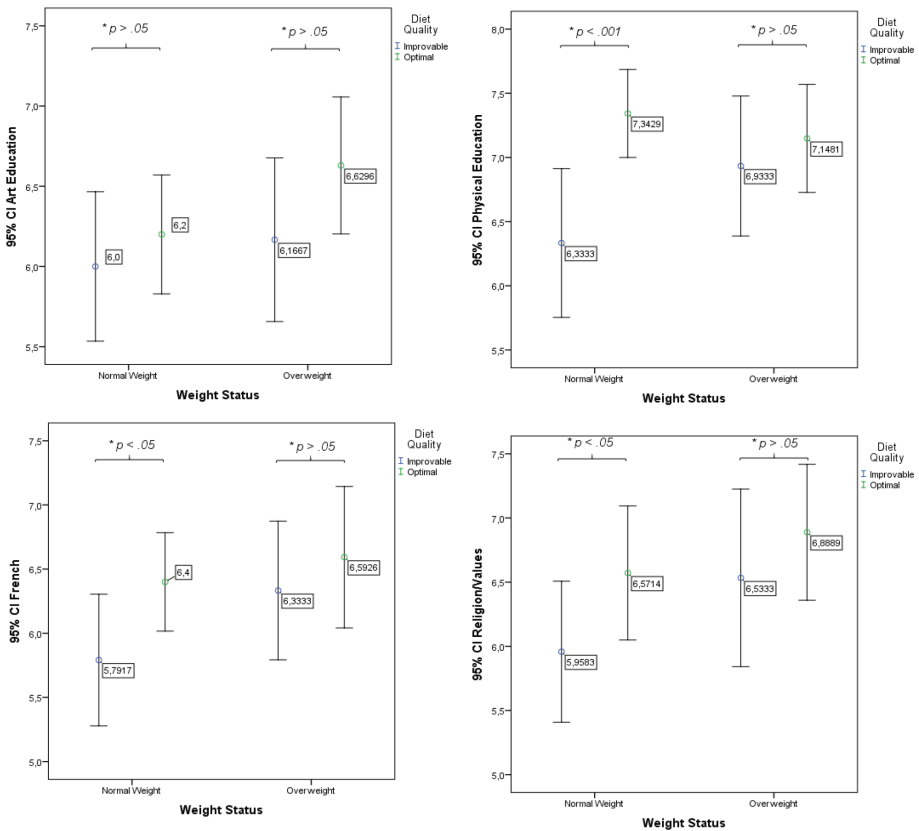
Figures I and II show the differences in academic performance between the diet quality groups (*improvable vs. optimal*) according to weight status (*normal-weight and overweight*). Normal-weight schoolchildren with good diet quality showed significantly higher scores in all academic scores compared to those with an improvable diet quality (with the exception of Art Education). However, those who were overweight showed no significant differences in academic subject scores (with the exception of Mathematics and English). It is prescriptive to note that interactions between weight status and diet quality (the Johnson–Neyman method was performed; $X*W$) were calculated in relation to academic subjects and were not significant for any subject (all $p > .05$) with the exception of Physical Education [$\beta = .124$; 95% CI = .102, .142].

FIGURE I. Differences in core subjects between adherence to the Mediterranean diet by weight status



Source: Compiled by author

FIGURE II. Differences in specific subjects between adherence to the Mediterranean diet groups by weight status



Source: Compiled by author

Discussion

The aim of this study was to determine the predictive power of diet quality on academic performance in all subjects taken by primary school children by looking at the moderating role of weight status. The main findings reveal that higher diet quality correlates with higher scores in all academic subjects with the exception of Natural Sciences, Art Education, Religion/Values and French.

As can be seen, there is a stronger relationship of diet quality with subjects that have a higher curricular weight. These results can be explained through neuroscience, understood as a discipline that combines psychology, pedagogy and neuroscience to explain how the brain works in learning processes. In this sense, our brain tends to understand better what is perceived by the senses, i.e. the concrete as opposed to the abstract. In this respect, exact areas such as mathematics or language study on many occasions' abstract properties, structures and relationships that require a higher level of difficulty than experimental sciences such as natural sciences, which resort to experiments or controlled tests to make a discovery (Decree 89/2014, of 1 August). In this line of argument, these results may be due to the fact that a higher quality of diet is positively related to elaboration strategies, organisational strategies, critical thinking, self-regulation, time and study habits, self-regulation of effort, and intrinsically oriented objectives (Chacón-Cuberos et al., 2018).

These aspects coincide with the findings of a meta-analysis, which indicates that improved dietary habits could be associated with more physically and mentally active behaviours, and thus lead to better overall health; aspects that could undoubtedly have an impact on higher academic performance. On the other hand, at the psychological level, Ekman (2021) indicates that thoughts, emotional patterns and psychological dynamics are strongly interrelated with learning. That is, if a person is aware of how they can influence and regulate their situation, they gain a sense of control and self-awareness that can be extrapolated to other contexts of their life, such as academic performance.

At the physiological level, a meta-analysis indicated that various micronutrients such as vitamin B12, zinc or iron may have a positive effect on subjects such as Mathematics, English, Geography, Science and Arts by improving certain executive functions (Meli et al., 2022). Other studies have also examined the relationship between breakfast and snack consumption and academic and cognitive performance in adolescent students, finding positive associations (Masoomi et al., 2020; Gaylor et al., 2021). Specifically, healthy eating behaviours predicted a greater increase in task-related activation of the right dorsolateral prefrontal cortex (Papasideris et al., 2020).

In turn, dietary patterns with low intakes of fish, fruit and vegetables, and high in fast food, sausages and soft drinks have been linked to poor cognition and academic performance. These differences remained significant for both the normal-weight and overweight groups. Similarly, break-

fast intake was associated for mathematics and science achievement (Vik et al., 2022). This study reported in mediation analyses that being hungry at school explained one-third of the decline in science achievement and more than half of the decline in mathematics achievement from 2015 to 2019. This could explain why in the present study, after adjusting the model for overweight, the significant relationship disappears in all subjects except Mathematics and English. Likewise, looking at the moderating role of weight status, the Johnson-Neyman method showed that there is no moderation of weight status in relation to diet quality and academic subjects, with the exception of Physical Education.

These results are partially similar to those obtained by Tapia-Serrano et al., (2021) where no interaction was found between weight status and diet quality in relation to academic indicators. This result may be due to the fact that the predominant methodology in the area of Physical Education is motor play and the attention for understanding the game and playing is high in all students (Rosa et al., 2018). That is to say, through play, the activation of perception and decision-making mechanisms is made possible, as well as the development of execution capacities; the acquisition of new motor skills is accessed, concepts are contrasted and the motivation of pupils to participate in activities and tasks that have an eminently recreational character, typical of the use of play and the forms played, without losing their priority function of training, is activated. In this sense, it has been described that the quality of the diet makes it possible to have more energy to carry out motor games and enables a greater capacity for attention. Therefore, it may have robust power to predict later academic success (Rosa-Guillamón et al., 2020). Hence, as schoolchildren have the necessary energy to play in Physical Education, there may be a relationship between diet quality and academic performance in this area.

In this study, in the predictive and differential analysis, it was observed that after adjusting the model to normal weight, this relationship between diet quality and academic performance is intensified in all academic subjects with the exception of Natural Sciences, Art Education, Religion/Values and French.

In this regard, Gabbianelli & Damiani (2018) suggest that the link between nutrition and learning may derive from the close interconnection between gut microbiota and cognitive mechanisms transiting the gut-brain axis. This study in adults provides evidence that 5-HT and BDNF mediate the association between overweight/obesity and executive control.

Therefore, these biological pathways may provide valid scientific data on the link between overweight/obesity and executive control (Si et al., 2021). However, Hernández-García et al., (2020) on the basis of the social structuring theory developed by Anthony Giddens indicate that academic performance and its relationship with health is a multifactorial problem, as it takes into account various factors: personal, social and institutional, as the individual and society work together.

In this sense, under the protection of the new educational law (Organic Law 3/2020, of December 29), the educational administrations must adopt measures so that physical activity and healthy eating are part of the behavior of children and young people during the school day, in the terms and conditions that, following the recommendations of the competent bodies, guarantee an adequate development to promote a healthy and autonomous life. Therefore, the educational system, in cooperation with the health system, must take responsibility for the physical and nutritional development of students insofar as they fall within their legal obligations. Undoubtedly, these professionals must assume to carry out intervention days in these early age stages in order to achieve the core objectives of the 2030 Agenda for Sustainable Development (Carrillo-López, 2022; García-Hermoso et al., 2022)".

Nevertheless, these findings should be interpreted with caution due to the fact that this study was not interventionist, but based on self-reported data, with unknown quality and quantity of food consumed daily by schoolchildren. In addition, the low sample size is undoubtedly another limitation. Similarly, it is difficult to infer a cause and effect relationship between attention and academic performance, since, as we have seen, there are confounding factors that are likely to influence these relationships and have not been considered in this study (such as socio-economic status). Thus, these effects could be related to environmental aspects and deserve to be further investigated in future studies.

Conclusion

Following the results obtained, it is concluded that: I) higher diet quality in primary school children is related to higher scores in all academic subjects with the exception of Natural Sciences, Art Education, Religion/Values and French; II) there is no moderation of weight status in relation to diet quality and academic subjects; III) students with normal weight

status who have good diet quality show significantly higher scores in all academic subjects compared to those with poor diet quality (except for Art Education). However, those who are overweight do not show significant differences in academic subject scores (except Mathematics and English) considering their diet quality. Based on these results, further intervention research should be conducted to reveal possible strategies and policies that would enhance positive behaviour change in relation to the recommended accurate dietary intake, with the aim of improving school performance and overall health throughout life. The awareness that habits during childhood become elements of daily life in adulthood, makes us realise the importance of the long-term consequences of maintaining healthy lifestyle habits, such as acceptable diet quality during childhood and adolescence on academic performance, hence the importance of these results.

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