Mediterranean diet and physical activity in Down syndrome pediatric subjects: the DONUT STUDY

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ABSTRACT

Introduction: Children with Down syndrome (DS) are characterised by peculiar dietary choices and approach to physical activity. The aim of this study is to quantify their adherence to the Mediterranean diet, their level of physical activity and lipid profile.

Methods: Cross-sectional study, involving 61 children affected by DS. Parents of the patients were requested to complete two questionnaires, Mediterranean Diet Quality Index in children and adolescents (KIDMED) and Godin Leisure-Time Physical Activity Questionnaire (Godin). In addition, children underwent a venous sampling to check their lipid profile.

Results: High scores on KIDMED and Godin were found and were associated with a reduced likelihood of being overweight or obese (0.001 < p < 0.077; 0.001 < p < 0.248). The level of physical activity and the probability of finding pathological HDL values in plasma were inversely related (0.001 < p < 0.263).

Conclusions: The DONUT study proves that KIDMED and Godin questionnaires can identify children affected by DS that can lead to develop inadequate anthropometric variables and low levels of HDL cholesterol. Moreover, the results of this study show that, despite potential difficulties in the pursuit of a correct diet and an adequate approach to physical activity, children with DS could achieve results that are substantially like those of non-DS children.

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Introduction

Children affected by Down syndrome (DS) have a higher prevalence of overweight and obesity compared to the healthy population (Basil et al. 2016). In this context, guidelines underline how diet and exercise are the cornerstones to paediatric obesity treatments (AbdAllah et al. 2013). Overweight and obesity in children with DS are partly due to their food choices. The tendency falls mainly on easy-to-swallow foods, meaning, consuming simple carbohydrates at the expense of fresh fruits and vegetables (AbdAllah et al. 2013). The aversion to certain foods could be related to altered perception of the consistency, taste, temperature or smell of food (Frazier and Friedman 1996). It is well known that Mediterranean diet strongly reduces the development of noncommunicable diseases starting in childhood, such as overweight and obesity (Pereira-Da-Silva et al. 2016; D’innocenzo et al. 2019). Unfortunately, adherence to the Mediterranean diet in paediatric subjects is generally declining, varying greatly from the country (Iaccarino Idelson et al. 2017). Regarding physical activity, peculiar characteristics and non-optimal health conditions in Down’s syndrome make participation in sport activities significantly less demanding. The syndrome’s peculiarities in this context are as follows: the reduced peak aerobic capacity (VO2peak) (Pitetti et al. 2013), macroglossia and metabolic limitations (Stemmons Mercer and Lewis 2001), hypotonia and ligamentous laxity which leads to excessive flexibility and also structural abnormalities of the feet, ankles, knees and pelvis (Holland 2014). On average, it is surprising how DS children tend to be less sedentary, for reasons related both to the greater amount of free time compared to non-DS children and to the greater prevalence of neuropsychiatric disorders (e.g. Attention-Deficit/Hyperactivity Disorder) that make...
children more restless and active (Fox et al. 2019). But paradoxically, DS children do not reach the guideline-recommended levels of 60 min/d of moderate to vigorous physical activity (Fox et al. 2019). Among cardiovascular risks, DS children seem to present a more unfavourable lipid profile than healthy subjects, regardless of body mass index (BMI). In particular, they show higher values of total cholesterol, LDL cholesterol and triglycerides and lower values of HDL cholesterol (Adelekan et al. 2012). Considering the previous statements, we designed a cross-sectional study in DS subjects’ follow-up in an outpatient clinic visit, performed over a six-month period at our hospital. The aim of our study is to quantify their adherence to the Mediterranean diet, their level of physical activity and the possible relationship with the anthropometric variables and the lipid profile.

Methods

Study design

It was a pilot observational study, 61 individuals with DS aged 2–17 years were enrolled. The population was selected from the follow-up outpatient clinic, with a focus on DS, performed at the Ospedale della Donna e del Bambino (OBD) in Verona (Italy) from December 2020 to May 2021. Exclusion criteria were represented by the presence of an active disease, such as walking or feeding difficulties or neoplasms or infectious diseases, at the time of the enrolment. The visiting chart included the following statements: 1) an explanation given to the candidates along with the parent(s)/legal guardian(s) of the purpose of the study and the verbal request for participation by an operator; 2) the signature of the parents/guardians (one or both, if present) consenting to the modalities and purpose of the study; 3) the compilation of the patient’s personal data sheet (sex, date of birth and ethnicity), the anamnestic data sheet, regarding known comorbidities by the parents/guardians (one or both, if present); 4) the parents/guardians (one or both, if present) compilation of the validated screening questionnaire for the survey on eating habits and adherence to the Mediterranean diet, “Mediterranean Diet Quality Index in children and adolescents” (KIDMED) (Serra-Majem, Ribas, Ngo, et al. 2004) (Figure A, Supplementary material) and the level of physical activity carried out in the subject’s free time “Godin Leisure-Time Physical Activity Questionnaire” (Godin) (Godin 2011) (Figure B, Supplementary material); 5) the medical examination performed by the doctor, including the investigation of the patient’s medical history, the medical evaluation, the measurement of the anthropometric parameters and the calculation of BMI (WHO 2006) and BMI z-score (Flegal and Cole 2013); 6) a venous blood sampling for laboratory analysis concerning the lipid profile (i.e. total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides), performed after fasting for at least 6 h.

The study was approved by the local Ethical Committee (DONUT STUDY: code 66508, 2020).

Statistical analyses

Statistical analyses were performed with STATA version 14 program (StatataCorp LLC, College Station, TX). The chi-square test allowed us to determine whether the observed rates for a categorical variable were significantly different from the expected rates. Literature data were then compared to the distribution in our sample. Categorical variables were also analysed using Fisher’s exact probability test. The dichotomous main outcome variable, normal-weight vs. overweight + obesity was modernised using logistic regression. The statistical significance level was set to $p < 0.05$.

Results

The demographic features of our study are represented in Table 1. Specifically, 61 subjects with DS were enrolled, including 30 males and 31 females. Twenty children were 2–4 years old, 41 children were 5–17 years old. Of 72% of children was Italian, 28% was foreign. The prevalence of overweight and obesity is shown in Table 2. In particular, 37 children (60.7%) were found to be normal weight. The total number of children with values above normal was 24 (39.3%), divided into 13 overweight children (21.3%) and 11 obese children (18%).

| Table 1. Demographic features. |
|---|
| Number of subjects | 61 |
| Sex |  |
| Female | 31 |
| Male | 30 |
| Age |  |
| 2–4 years | 20 |
| 5–17 years | 41 |
| Origin |  |
| Italy | 44 (72%) |
| Morocco | 5 (8.2%) |
| Moldova | 2 (3.3%) |
| Afghanistan | 2 (3.3%) |
| Sri Lanka | 2 (3.3%) |
| Pakistan | 2 (3.3%) |
| Serbia | 1 (1.6%) |
| Nigeria | 1 (1.6%) |
| Vietnam | 1 (1.6%) |
| Romania | 1 (1.6%) |
The distribution of answers to KIDMED questionnaire is reported in Figure 1.

Regarding results of the KIDMED questionnaire, 65.6% of children with DS had a moderate adherence to Mediterranean diet, followed by high adherence (24.6%) and low adherence (9.8%). As shown in Figure 2, the association between the KIDMED questionnaire of adherence to the Mediterranean diet and the “weight” parameter showed that lower adherence to the Mediterranean diet (red line) represents an increasing risk factor for the development of overweight and obesity. Subsequently, the probability of falling into the pathological category is greater in those with lower or moderate adherence to the Mediterranean diet, compared to those with high adherence. The relative risk being 9–13% (0.001 < p < 0.077). In addition to this, it is possible to observe how this probability, in absolute terms, increases with increasing age.

Regarding the Godin questionnaire, 52.5% had a moderate level of physical activity, followed by low physical activity (31.2%) and high physical activity (16.4%). As shown in Figure 3, the association between the Godin questionnaire and the “weight” parameter showed that greater sedentariness (red line) represents an increasing risk factor for the development of overweight and obesity. This outcome shows the probability of falling into the pathological category is greater in those who are more sedentary or moderately active, compared to those who are very active. The relative risk being 14–23% (0.001 < p < 0.248); this probability, in absolute terms, increases as age increases. In addition, analysing the relationship between Godin questionnaire on physical activity levels and HDL values (Figure 4), we found that as the Godin score increases, the percentage probability of having pathological HDL values decreases. This reduction ranges from 42% probability at the Godin score of 0–10% at the score of 40 (0.001 < p < 0.263).

**Discussion**

We wondered if the eating and physical activity habits of DS-children were peculiar enough to justify their higher prevalence of overweight and obesity. In order to find an answer, we compared similar studies in the literature that used the same KIDMED and Godin questionnaires, analysed similar populations of non-DS children and reported the results.

As for the Mediterranean diet, the comparison was possible and made with studies conducted both in Italy – North (Rosi et al. 2017; Archero et al. 2018; Buja et al. 2020) and South (Mistretta et al. 2017; Bonaccorsi et al. 2020; Grassi et al. 2020) (Figure 5) – and in the Mediterranean basin (Serra-Majem, Ribas, García, et al. 2003; Serra-Majem, Ribas, Ngo, et al. 2004; Chatzi et al. 2007; Kontogianni et al. 2008; Lazarou et al. 2009; Mariscal-Arcas et al. 2009; Erol et al. 2010; Farajian et al. 2011; Sahingo and Sanlier 2011) (Figure 6). Despite the proven selectivity in food choices reported in the literature, comparing the KIDMED scores, it was possible to note how our DS subjects tend to follow the Mediterranean diet in a

![Figure 1. Distribution of responses to the 16 questions on the KIDMED questionnaire.](image-url)
similar way to non-DS children from the same geographical area of Northern Italy ($0.2 < p < 0.96$), but differ from Southern Italy ($p < 0.01$).

The comparison with other Mediterranean countries showed how our population of DS children is significantly less adherent to the Mediterranean diet than Spanish children ($0.001 < p < 0.004$), but more adherent than children from Crete, Cyprus and Greece ($0.001 < p < 0.0038$). Lastly, the comparison with Turkish-KIDMED scores was contradictory. Ultimately, it was found that the children population of Northern Italy (including our population of DS-children) is more adherent to the Mediterranean diet than Southern Italy and other European countries.

These results underline that it is not necessary to consider a specific diet for DS subjects who need nutritional intervention to correct their body weight, but instead create guidelines that can be applied to the general paediatric population. Specifically for our population, it is possible to improve the KIDMED score considering the 16 answers in Figure 1.

Regarding the Godin questionnaire, an in-depth comparison with other populations investigating physical activity’s levels was more difficult because there are only a few studies in literature in which a paediatric-age population was given the same questionnaire, but the results were reported in a different way. The only two comparable studies were performed in Saudi Arabia (Alhusaini, BuraGadd, et al. 2020; Alhusaini, Melam, et al. 2020). The results were conflictual (respectively, $p < 0.001$ and $p = 0.615$), but they place our population in an intermediate position with a high percentage of subjects following a moderate physical activity.

The core of our study was to analyse if and how the KIDMED and Godin questionnaires were actual reliable methods for early intervention of overweight and obesity in children with DS. Referring to the

![Figure 2](image1.png)

**Figure 2.** Probability of overweight/obesity in case of medium and low adherence to the Mediterranean diet and high adherence.

![Figure 3](image2.png)

**Figure 3.** Probability of overweight/obesity at moderate and low physical activity and high activity.
results, the probability of falling into the pathological category of overweight and obesity is greater in those with lower or moderate adherence to the Mediterranean diet, along with those who are more sedentary or moderately active. This probability increases with an increasing age. In line with what has been described in the literatures (Hills et al. 2011; AbdAllah et al. 2013; Pereira-Da-Silva et al. 2016; Styne et al. 2017; D’innocenzo et al. 2019), even in our study, low adherence to the Mediterranean diet and reduced levels of physical activity are related to worse anthropometric outcomes, resulting in increasing risk factors for overweight and obesity. This suggests that the KIDMED and the Godin questionnaires can be useful tools for the everyday clinic, making it easier to notice subjects whose habits put them at a higher risk to develop overweight or obesity.

Following what has been stated in the literature (Ruiz-Ramie et al. 2019) that higher levels of physical activity reduce the probability of obtaining
pathological (i.e. reduced) HDL values as focussed in the Godin questionnaire. In fact, we found an interesting association between physical activity (measured through the Godin questionnaire’s score) and the lipid profile. As said before, we found that as the Godin score increases, the probability of having pathological HDL values decreases (this reduction ranges from 42% probability at the Godin score of 0–10% at the score of 40). Therefore, the Godin questionnaire can be seen as a useful tool not only to predict anthropometric variables – referring to overweight and obesity – but also important biochemical parameters, such as HDL cholesterol.

Our study is the first to show a direct relationship between the scores of the two validated questionnaires and overweight and obesity along with HDL cholesterol values. All this was tested in a peculiar population, such as children with Down’s syndrome, who are at higher risk of developing overweight and obesity and an unfavourable lipid profile. Anyway, this study has some limitations. First, the low simple size, because data were collected in a single paediatric unit. Second, the subject involved belongs only to Northern Italy. Finally, anamnestic information about the data of the questionnaires and exclusion criteria are self-reported by the parents of children, so some patients could be lost or misclassified.

**Conclusions**

Since the weight of the child affects the future health of the adult, it is important to find the right strategies to intervene those at a higher risk of developing overweight and obesity and start treatment as early as possible (Simmonds et al. 2016). Literature shows that subjects with DS are part of this high-risk category. The DONUT study could prove that simple tools, such as the Mediterranean Diet Quality Index in children and adolescents and Godin Leisure-Time Physical Activity Questionnaire questionnaires are able to identify those with risky eating and physical activity that can lead to develop inadequate anthropometric variables and low levels of HDL cholesterol. The results of our study, which involved subjects followed at a dedicated outpatient clinic, show that, despite potential difficulties in the pursuit of a correct diet and an adequate approach to physical activity, children with DS could achieve results that are substantially similar to those of non-DS children. On the contrary to what might be expected, they are neither particularly selective in their food choices nor sedentary.

Anyway, it is necessary to consider that this has a low sample size and subject involved belongs to Northern Italy. For this reason, the specific strategy for the development of future studies could be the use of a larger sample size from different geographic areas, like Southern Italy.

In conclusion, this study leads to two endpoints. First, we should not think of DS as a limitation but rather, as a criterion for choosing the sport and diet best suited to the needs of the individual child. The second inspires a wider use for the two questionnaires, not limited to children with DS, but for all children in general. The existence of universally useful
questionnaires can be the first useful tool for paediatricians to fight a problem as widespread as obesity and overweight.

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