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Worldwide adherence to Mediterranean Diet between 1960 and 2011

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Abstract
Background: From the 1960s to the early 21st-century adherence to the Mediterranean diet (MD) declined around the world. This was partly due to the westernization of eating habits. However, in the last decade a new variable came into play, the economic crisis, which may have affected dietary patterns.


Methods: Data was obtained from the Food and Agriculture Organization Food Balance Sheets in three study periods: 1961-1965, 2000-2003 and 2004-2011. The Mediterranean Adequacy Index (MAI) was calculated for 41 selected countries using the averages of available energy intake for different food groups. Changes in MAI indicated the trends in adherence in the different periods.

Results: In many countries, MAI deteriorated from 1961 to 1965 and 2004 to 2011, yet an increase was observed in 16 countries. Between the last two observation periods, MAI values stabilized in 16 of the 41 selected countries. Regional rankings for the three study periods based on descending MAI scores were: Southern Mediterranean, Mediterranean Europe, Central Europe and Northern Europe.

Discussion and Conclusions: Adherence to the MD significantly decreased between 1961-65 and 2000-03, whereas from 2004-2011 there was a stabilization of MAI values and even an increase among 16 countries. Efforts are needed to preserve the dietary traditions and lifestyle habits within the Mediterranean region in order to counteract increasing rates of chronic disease.

Key words: Mediterranean Diet, Mediterranean Adequacy Index, Food Balance Sheets, Westernization, Dietary patterns, Economic crisis; Mediterranean Diet adherence.
Abbreviations used: Mediterranean Diet (MD), Mediterranean Adequacy Index (MAI), Food balance sheets (FBS), Food and Agriculture Organization (FAO), World Health Organization (WHO), Gross National Product (GNP).

Introduction

The Mediterranean Diet (MD) is widely considered the overall dietary pattern of the Mediterranean basin, which spans from Southern Europe, to Northeast Africa (1,2). The abundance and variety of traditionally healthy foods in the Mediterranean region may be partly attributed to the strategic location along the north 40th parallel, which passes through the Mediterranean Sea, Asia, Japan, North America and the Iberian Peninsula. The temperate climate conditions paired with a dry season are characteristics of the Mediterranean region. Culinary traditions and foods (such as the cultivation of the triad wheat, grapes and olives) of the countries along the northern and southern 40th parallel overlap with those inherent to the Mediterranean region. For example, the vast olive groves of California; the fine wines of Chile, Argentina, South Africa and Australia; and the oranges of China all emulate aspects of the Mediterranean dietary pattern.

The overall MD vastly described elsewhere is primarily a plant-based diet with several common features (3-5): moderate consumption of dairy products, fish, eggs, white meat and wine; occasional consumption of red and processed meat, and sweets; and use of olive oil as the principle fat source.

The traditional MD, defined in the 1960s, has evolved over time due to social and cultural factors (4). Recent Spanish and Italian studies have shown how economic factors, such as the global financial crisis may have played a role in altering dietary habits (6,7). Epidemiological data suggest that higher quality diets are associated with higher costs (8-10). Thus, it should be determined...
whether the degree of adherence to the MD has changed due to the economic recession, and whether it is necessary to develop measures to safeguard the traditional dietary habits.

The modern MD pyramid (5) which promotes a return to the traditional diet, incorporates various food components and other elements related to the lifestyle behaviors and cultural traditions. The MD pattern is widely recognized as a healthy, prudent diet, and high adherence to the diet has been associated with improved health and reduced risk of chronic disease (11-13). Preserving the traditional dietary heritage of the Mediterranean basin has been cited as an effective, sustainable and economically viable method for promoting health (14). Many food indexes and scores have been developed to assess adherence to healthy dietary patterns (15). The Mediterranean Adequacy Index (MAI) is one such index, and it has been used to study the adherence of a country or a population to the MD (16-20).

The present study was performed within the framework of the “Paralelo 40-World Mediterranean Diet Surveillance System” with the aim of evaluating adherence to the MD in 41 selected countries using the MAI score, and to assess worldwide trends over the last 50 years, including the 3 years immediately following the 2008 economic crisis.

Methods

Study population

The data were obtained from annual food balance sheets (FBS) from the FAOSTAT database (21), which provides information about each food item available for global human consumption. The total food available for human consumption per country is based on the total quantity of foodstuffs produced and imported minus exported food items or those used for non-human use or lost during
storage or transportation. The annual kcal/capita/day was used to assess the overall pattern of each nation’s food supply and to compare that pattern over time and among countries (17, 22).

In the present study, 169 countries were included in the calculation of a worldwide MAI score. MAI scores were calculated for 41 selected countries and these countries were further divided into Mediterranean and Non-Mediterranean categories. The Mediterranean category was divided into 2 subcategories: Mediterranean Europe (Albania, Cyprus, France, Greece, Italy, Malta, Portugal, Spain, and Turkey) and Southern Mediterranean (Algeria, Egypt, Israel, Lebanon, Libyan Arab Jamahiriya, Morocco, Syria, and Tunisia). The Non-Mediterranean regions were further divided into Central Europe (Austria, Bulgaria, Czechoslovakia, Germany, Hungary, Poland, Romania, and Switzerland), Northern Europe (Denmark, Finland, Ireland, Norway, Sweden, and the United Kingdom) and Other World (Argentina, Australia, Brazil, Canada, Chile, Islamic Republic of Iran, Japan, Mauritania, South Africa, and the United States). Geographical, cultural and socio-economic factors were considered when classifying countries (17). Czechoslovakia underwent political changes between the study periods and was therefore divided into the Czech Republic and Slovakia. The data for the last two periods were calculated using the sum of these two countries and are referred to as Czechoslovakia in this paper (22).

**Dietary assessment**

The mean energy estimates were calculated for each time period and were derived from the calories/capita/day values per year and per country as reflected in the FAO Food Balance Sheets. The average energy intake was calculated for the most recent study period of 2004-2011 and then compared with the data obtained in the previous periods (1961-1965 and 2000-2003). The calculation was done according to da Silva et al (20). Adherence to the MD was assessed using the MAI tool defined by Alberti-Fidanza et al. (23) adapting the classification of the Mediterranean and Non-Mediterranean products. The MAI is calculated by dividing the energy intake provided by the total sum of the Mediterranean food groups by the energy provided by the Non-
Mediterranean food groups (18, 24, 25). Since each time period spans a number of years, the
country MAI scores for each period were calculated as the mean of the yearly MAI scores for that
country within the time period assessed. For each subcategory a mean MAI value was derived from
the mean MAI scores per country within that subcategory. A higher MAI value indicates a greater
adherence to the MD.

The Mediterranean food group included the following food items: olive oil, olives, cereals
(excluding beer), starchy roots, herbs, spices, fruit, vegetables, nuts, fish, seafood, legumes, and
wine. The Non-Mediterranean food group included: sugar, sweeteners, alcoholic beverages (except
wine and beer), meat, beer, sugar crops, oil crops, offal, stimulants (coffee, cocoa beans, tea),
animal fat, other sources of fat (excluding olive oil), and miscellaneous products. Eggs and dairy
products were excluded from evaluation since they are considered elements common to all dietary
patterns, and data on the different dairies was not available. Only primary foods such as milk were
included in the FBS.

**Statistical methods**

For the statistical analysis, an F-test was applied to first evaluate whether the variance of the
populations was equal. Following the F-test, a Student’s t-test for independent samples, assuming
equal or unequal variances depending on the result of F-test, was used to verify the differences
between the mean MAI scores among subcategories in the corresponding time periods. For paired
samples, the Student’s t-test was used to compare the mean MAI value of each category between
time periods. Significance was set at 0.05.

**Results**

The MAI scores of 169 countries were calculated by comparing the proportion of calories per capita
between the Mediterranean and Non-Mediterranean food groups (Figure 1). Forty-one of these
countries were further divided, based on region, for subcategory analysis.
Comparison between subcategories

The worldwide MAI value of the 169 countries decreased from 2.86 in the first period (1961–1965) to 2.03 in the third period (2004-2011). The mean MAI values of each time period for the 41 countries included in our analysis were 2.35 (SD 1.47), 1.51 (SD 0.88) (P<0.05) and 1.47 (SD 0.84) (P>0.05) for periods 1 (1961-1965), 2 (2000-2003) and 3 (2004-2011), respectively (Table 1).

During the first time period, the MAI for the Mediterranean category (3.46) was higher than the worldwide MAI (Table 1). In the Non-Mediterranean category, the MAI was 1.57, lower than that of the worldwide MAI. However, in the second time frame (2000-2003), the Mediterranean category and the world shared the same MAI value of 2.03, while the MAI value in the Non-Mediterranean category fell to 1.14. In our current analysis of the 2004-2011 time frame the Mediterranean (2.00) category scored a lower MAI value than the worldwide mean. Only the countries within the Southern Mediterranean subgroup showed a higher mean MAI value than the world MAI.

Comparison within the Mediterranean category

Of the 17 countries within the Mediterranean category, the mean MAI score from the first, second, and third time frames decreased from 3.46 to 2.03 (P<0.01) to 2.00 (P<0.01), respectively. From the 1960s until the most recent time frame, the MAI scores significantly decreased in both the Southern Mediterranean (p=0.005) and Mediterranean Europe subcategories (p<0.001) (Table 2). Between the 2000-2003 and 2004-2011 periods, the mean MAI score for the Mediterranean countries decreased, albeit not significantly (Table 2). Within the same time frame, the mean MAI scores in Mediterranean Europe decreased, but increased in the Southern Mediterranean, although not significantly.

Comparison between Mediterranean and Non-Mediterranean countries
Comparing the Mediterranean with the Non-Mediterranean categories, the Mediterranean countries yielded the highest MAI values in all the periods studied. Between each period both groups showed decreases in MAI scores. However the changes between the last 2 study periods were not statistically significant (Table 2).

**Comparison within subcategory groups**

Between the first and last study periods, the MAI score of Mediterranean Europe, Southern Mediterranean, and Central Europe significantly decreased. Over the same periods, however, there were non-significant increases in MAI scores in Northern Europe (Table 2). By contrast in Southern Mediterranean countries the high MAI value of the 5 subcategories was maintained during the three study periods.

**Ranking of countries by MAI**

Ranking the different regions according to the MAI, for the three study periods was as follows: Southern Mediterranean, Mediterranean Europe, Other World Countries, Central Europe and Northern Europe.

During the 1961–1965 period, the MAI values in 14 of the 41 countries were higher than 3.00 (Table 3). Twelve of these countries were from the Mediterranean category; and three countries in the Mediterranean Europe subcategory (Greece, Albania and Turkey) had MAI scores over 5.00. The remaining 2 countries, Japan and Romania, were from the Non-Mediterranean group. Between 1961–1965 and 2000–2003, the MAI scores in all 17 of the Mediterranean countries decreased. Turkey (2.80), Albania (2.51) and Greece (2.04) led the Mediterranean Europe group with the highest MAI scores for period 2. The number of Non-Mediterranean countries ranked within the top 15 according to the MAI scores doubled from two to four. The MAI scores in 8 (33%) of the Non-Mediterranean countries increased, while scores decreased in the remaining 16. The countries with increased MAI values were from Northern Europe and Other World subcategories. Romania
(2.02) and Bulgaria (1.20) ranked highest among the Central European countries, despite showing a large decrease compared to the first study period. Greece, Albania, Turkey, and Japan presented the greatest reduction in MAI values between these periods. During the first study period, these 4 countries ranked within the top 6 MAI values, but fell to the 5th (Turkey), 7th (Albania), 10th (Greece) and 16th places (Japan), thereafter (Table 3). Iran showed the largest increase (0.78) in the MAI score between the first two study periods, improving its ranking from 16th to 2nd. While in Morocco, Malta and France the MAI scores decreased and showed the least movement away from their respective original values.

From 2000 to 2003, no country achieved a MAI value over 5.00 and Egypt held the highest MAI value at 4.09. The number of countries with MAI scores of 3.00 or higher decreased from 14 to only 3 (Egypt, Iran and Morocco) by the end of the last period (Table 3).

Between the 2000-2003 and 2004-2011 periods, the MAI scores in 6 countries (35%) within the Mediterranean group increased, and decreased in the remaining 11 countries. Within the same time frame, the MAI values of 10 (42%) of the Non-Mediterranean countries increased, thereby doubling the number of countries in which the MAI value had increased. The largest variations in MAI values were the increased scores reported in Egypt (0.27), Algeria (0.27) and Israel (0.16) and the decreased scores in Iran (-0.66), Turkey (-0.29) and Romania (-0.43) (Figure 1). Egypt ranked the highest among all the countries while Italy and Portugal maintained MAI values closest to their respective previous values, although the scores had fallen in both countries. Greece continued to rank 10th among all the countries selected. As in the second period, France ranked last among the Mediterranean countries from 2004 to 2011.

In the most recent study period (2004-2011), none of the countries attained a MAI value of 5.00 or higher. Only Egypt maintained a MAI score above 4.00, exhibiting a slight increase since the last survey (4.09 to 4.36). There were 2 countries with MAI values above 3.00, which were Morocco (3.17) and Algeria (3.07) (Table 3). Among the top 15 countries, ranked according to MAI score,
7 countries were from the Southern Mediterranean subcategory and 4 from Mediterranean Europe; the same as in the previous period. Romania (1.73) and Bulgaria (1.17) maintained the highest MAI values within the Central European subgroup, although these values had decreased in both countries. The United States had the lowest MAI score in all 3 surveys.

In only 5 countries (12%) (Denmark, Sweden, the United Kingdom, Australia and Canada) the MAI scores increased from 1961–1965 to 2000–2003, and again between 2000-2003 and 2004-2011. Among these countries, the MAI scores significantly increased in Canada (0.71 to 0.80; p<0.01) and the United Kingdom (0.67 to 0.91; p<0.001). However, since these countries started with low MAI values their most recent mean MAI scores still fall below the mean MAI scores of the Mediterranean countries during any time period.

Discussion

The adherence to the MD over a 50-year period was analyzed between the first study in 1961-1965 to the most recent surveys in 2000-2003 and 2004-2011 in 169 countries. Over this time, many countries had departed from the MD. However this trend slowed between the last two periods where the decreases in MAI values stabilized in 16 out of 41 selected countries.

Mediterranean versus Non-Mediterranean group comparisons

The Mediterranean group shifted away from their traditional MD pattern between all the study periods. This overall trend in departure from the MD pattern within the Mediterranean region has been described in previous studies (2, 26, 27). However, the present study shows that between 1961-1965 and 2004-2011, this movement away from the MD diet was less pronounced, suggesting a slowed digression over the last decade, as shown in the previous study by da Silva et al. 2009 (20).

We found that the movement away from the MD was most pronounced in the Mediterranean Europe, Southern Mediterranean and Central Europe subcategories. Within the Mediterranean
group, the Mediterranean Europe subcategory showed the most pronounced deterioration in the MD pattern while the Southern Mediterranean subcategory maintained the highest adherence to the MD; this was similar to what has been described in a previous study (27). Therefore, the difference between the MAI scores in Southern Mediterranean and Mediterranean Europe increased over time.

**Country subgroup comparisons**

From the 60s to today, the Mediterranean countries with the highest MAI values have transitioned away from their traditional dietary patterns, as described previously (17). However, a direct comparison cannot be made given the differences in the food item classifications. Those Mediterranean regions have undergone significant cultural, social and political changes, which may have influenced the dietary transition and changes in food habits (2, 26). From the 1960s to the present study, the most significant changes in energy intake have been related to the decrease of carbohydrate sources associated with increases of fat sources, particularly of animal origin. As a result, the proportion of calories from Non-Mediterranean foods has increased. Even so, the MAI values in Mediterranean Europe were consistently higher than those of the Northern Europe and Central Europe subgroups throughout the three time periods studied. Although the availability of most Mediterranean foods has increased, the availability of the Non-Mediterranean foods, mainly vegetable oils, sugar, sweeteners and meat, can contribute to the deterioration of the MD pattern (28). This shift also illustrates how food habits have become more homogeneous globally.

Within several of the Non-Mediterranean countries, the MAI scores increased between the first and the last study periods, although, the Northern European countries maintained the lowest MAI scores over the last 50 years. This shows that Non-Mediterranean products contribute more energy
to the diet than Mediterranean products (28). As reported in other studies, in Northern Europe the MAI scores have risen since the early 1960s (20, 29, 30).

**Country rankings**

Comparing countries, Greece showed the greatest decrease in the MAI score with a fall in the ranking from first to tenth place since the 1960s. However from the second to the third period, the MAI only slightly decreased and appears to have stabilized. Egypt stands out as having the highest MAI of all the selected countries for both the second and third periods, with even slightly increased scores, indicating a steady increase in adherence to the MD. This complements previous studies from the World Health Organization which suggested that Egypt has the closest adherence to dietary recommendations (2,31). This may be indirectly associated with its low Gross National Product (30), and the influence this has on the type of foods available.

Central European countries such as Romania and Bulgaria with a historically high MD adherence showed a large decrease in MAI. The mean MAI of Central Europe is now close to 1.00, which illustrates that the proportion of calories derived from Mediterranean and Non-Mediterranean foods is nearly equal. Traditionally, the food patterns of these countries shared many characteristics with the Mediterranean dietary pattern (2, 32), however, the movement away from these foods continues to increase.

**Mediterranean-type dietary pattern over the Mediterranean region**

The broad "Other World" category includes a heterogeneous group of countries with a variety of dietary patterns, traditions and cultures. This group crosses continents and includes countries from North and South America, Asia, and Africa. Within this category, Iran showed the greatest increase in MAI values since the start of the study, moving from 15th to 2nd to 4th place in the MAI rankings by country over the three respective time frames.
Over the 50-year period, MAI scores increased in only 10% of countries between the periods of 1961–1965 and 2000–2003 and again between 2000-2003 and 2004-2011. None of these were Mediterranean countries. All of these countries were from the Non-Mediterranean group: Denmark, Sweden, the United Kingdom, Australia and Canada. The movement towards higher MAI scores among these countries suggests that consumers are striving to incorporate more Mediterranean foods as part of a healthy dietary pattern.

The dietary pattern of both Japan and Iran share common MD features such as a high consumption of cereals, vegetables, fruit, and fish (18). Although the principle Japanese grain is rice and the Mediterranean grain is wheat (33), indicating that both nutrient profiles are represented by a high consumption of cereals, the MAI values in Japan within in both periods showed a similar change in score. As with Mediterranean countries, Japan has also changed its traditional dietary food pattern, which is echoed in the diet of the population and the quantity and type of products consumed (33-35).

**Mediterranean Diet Adherence and Economic Recession**

The relationship between the economic recession and dietary pattern was explored. A large Italian population study reported an association between adherence to the MD and socioeconomic factors, with greater wealth being associated with increased adherence to the MD. (6). Another Italian study concluded that adherence to the MD was lower in subjects reporting a negative impact of the economic crisis on diet as compared with those declaring no effect, describing a reduced expenditure on foods such as fresh fish, nuts and vegetables (36). Greece, Spain and Portugal have been affected by the economic downturn during the last survey period from 2004-2011. The MAI increased in Spain, remained stable in Portugal and decreased in Greece. Despite these trends, none of these changes were statistically significant from the 2000-2003 period. Other factors than those related to the economy, such as education, age and urbanization, may have played a role in dietary changes (37). Spanish research (7) suggests that the economic downturn was associated with
decreased consumption of fish, fruit and vegetable and increased consumption of legumes for the first time since the 1960s.

According to an FAO report on the financial crisis on nutrition (38) the economic crisis has shifted the composition of food expenditures toward staple foods and away from animal-based foods such as meat. Thus, effect of the economic crisis may have affected nutrition status worldwide by possibly avoiding excesses, reducing portion sizes, or prioritizing staple foods.

Strengths and limitations

Strengths and limitations regarding the methodology have been explained in more detail in the previous study (20, 28). The validity of the MAI has been confirmed by Fidanza et al. (24), who demonstrated a relationship between the MAI value and both total mortality rates and 25-year coronary heart disease mortality rates of populations in 10 European countries followed over 10 years. The advantage of calculating the MAI based on the energy provided by foods, is that the various energy densities of foods do not influence the overall dietary consumption patterns. However, the MAI can be calculated using g/day, although the values will be different from those calculated as a percentage of total energy due to variability in energy densities of foods and beverages.

One of the limitations of the MAI is the variability in the categorization of food groups classified as Mediterranean and Non-Mediterranean (39). Additionally, the MAI reduces the MD as a whole to a simple list of products, which does not take into account the different frequency and proportions of the food items within each food group (25), how they align with the MD recommendations or the influence of these foods on the diet-disease relationship (24). For example, both red meat and white meat are included in the broad category of meats, rather than being separated (31). Certain food items, such as eggs and dairy products, were not included in our calculation of the MAI, partly because data from the FBS represents raw food products or primary
ingredients which do not necessarily fall into the food groups used to construct the MAI. For instance, the data for milk but not dairy products and the availability of eggs is presented but not the food groups in which it is found, such as cakes and pastries. Additionally, evidence regarding the health benefits of dairy products is somewhat controversial (40), and the category of dairy is not considered exclusive to only one dietary pattern.

The limitations of the FBS are tied to the inaccuracy of the underlying data sources (22, 29) (such as data on production, storage, losses and crops). Secondly, an inherent limitation of the FBS is that the data calculates an estimate of the total energy available for human consumption and not necessarily energy consumed (29). Indeed, two comparative analyses found that the FBS tends to overestimate food consumption as compared to individual dietary surveys (41, 42). The third limitation of the FBS is the inability to quantify food availability based on subgroups of the population, such as age, gender and education, since energy estimates are provided per capita (29). Lastly, figures related to energy provided by home production or consumption by tourists, are not taken into account. Despite this, the FBS provides a cost-efficient and effective method of assessing longitudinal comparisons of dietary patterns within and between nations (17, 29).

**Conclusions**

Adherence to the MD decreased significantly between the 1961-65 and 2000-03 study periods. The last period from 2004-2011 showed a stabilization of MAI values, and in 16 countries MAI values increased. The MD represents one of the healthiest dietary patterns in the world and has been recognized as an effective tool for improving public health, quality of life and decreasing the incidence of chronic diseases, such as cardiovascular disease, diabetes, obesity, cognitive impairment, and cancer (11). This is especially relevant for using the Mediterranean Diet as a model in comparison to the Western dietary pattern, rich in animal-based foods and sugars (43,44).
Maintaining MD patterns are crucial for public health. Governments and non-governmental organizations should promote health and agricultural policies (29), and take into account the inevitable effect of the economic crisis on dietary habits of the population (29,45,46,47). Therefore, an effort to preserve the dietary traditions and lifestyle habits within the Mediterranean region, and by extension the 40th parallel, is paramount to counteract increasing rates of chronic disease. Such efforts would not only benefit public health, the economy, and the environment, yet would also provide a means of preserving the dietary heritage and gastronomic traditions of the Mediterranean region.

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9.


Table 1. Descriptive statistics for all studied country groups in all studied periods (1961-65, 2000-03 and 2004-11).

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<th>Mean ± SD</th>
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<tr>
<td>World</td>
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<tr>
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<td>North Europe</td>
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<td>Other World Countries</td>
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<td>1.92 ± 1.16</td>
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NA: Not Available
Table 2. P values for all the country groups studied between the periods of 1961-65 and 2000-2004 and 2000-2003 and 2004-2011.

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<td>Other World Countries</td>
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<td>0.27528</td>
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p > 0.05 no significant changes
Table 3. Ranking of countries by the Mediterranean adequacy index (MAI) in the three study periods.

<table>
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<th>Countries</th>
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<th>2000-03</th>
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<th>2004-11</th>
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<td>MAI</td>
<td>Ranking</td>
<td>MAI</td>
<td>Ranking</td>
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<td>Greece</td>
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<td>2.04</td>
<td>10</td>
<td>1.87</td>
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<td>7</td>
<td>2.51</td>
<td>6</td>
<td>2.37</td>
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Figure 1. Variation of the Mediterranean adequacy index (MAI) in all countries between the periods of 2000-2003 and 2004-2011.