Article

Adherence to a Mediterranean Diet Is Inversely Associated with Anxiety and Stress but Not Depression: A Cross-Sectional Analysis of Community-Dwelling Older Australians

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Abstract: Diet quality may be an important modifiable risk factor for mental health disorders. However, these findings have been inconsistent, particularly in older adults. We explored the independent associations between adherence to a Mediterranean diet (MedDiet) and severity of symptoms related to depression, anxiety and stress in older adults from Australia. This was a cross-sectional analysis of older Australians 60 years. MedDiet adherence was assessed using the Mediterranean Diet Adherence Screener (MEDAS), and the Depression, Anxiety and Stress Scale (DASS 21) was used to assess the severity of negative emotional symptoms. A total of n = 294 participants were included in the final analyses (70.4 6.2 years). Adherence to a MedDiet was inversely associated with the severity of anxiety symptoms (= 0.118; CI: 0.761, 0.012; p = 0.043) independent of age, gender, BMI, physical activity, sleep, cognitive risk and ability to perform activities of daily living. Furthermore, MedDiet adherence was inversely associated with symptoms of stress (= 0.151; CI: 0.680, 0.073; p = 0.015) independent of age, gender, BMI, physical activity and sleep. However, no relationship between MedDiet adherence and depressive symptoms was observed. We showed that adherence to a MedDiet is inversely associated with the severity of symptoms related to anxiety and stress but not depression. Exploring these findings with the use of longitudinal analyses and robust clinical trials are needed to better elucidate these findings in older adults.

Keywords: Mediterranean diet; ageing; mental health; depression; anxiety; stress

1. Introduction

With the unprecedented global trend in population ageing [1,2], supporting healthy ageing is paramount. Although different conceptual approaches have been used to define healthy ageing, the World Health Organization recently introduced the concept of intrinsic capacity, resulting in a shift away from a deficit-orientated to a function-based approach [2]. As such, intrinsic capacity is largely defined as a composite measure of an individual's physical and mental capacity that an individual can draw upon throughout their lifespan [3,4]. Nevertheless, despite population ageing, increased longevity does not accompany healthy ageing. Non-communicable diseases and multi-morbidity are major contributors to years lived with disability, with musculoskeletal conditions being a major contributor to global disability [5,6]. Literature supporting the benefits associated with the maintenance of physical function and strength with age is compelling [7–9]. However, non-communicable diseases, including musculoskeletal disorders, only partially contribute to years lived with disability, with mental health disorders being a major influence for disability and disease burden, particularly in older adults [10,11].

Mental health disorders, including depressive and anxiety disorders, are commonly reported in older adults [12–14]. Despite the marked heterogeneity in its clinical presentation [15], risk factors for depression and anxiety in older adults can be identified as biological, psychological and social risk factors. Multi-morbidity, low self-perceived quality of life, reduced autonomy, functional disability, financial stress, inadequate social networks, social isolation and female gender have all been identified as important risk factors for both the prevalence and incidence of anxiety and depression in older people [14]. Furthermore, there is meta-analytic evidence suggesting a bi-directional relationship between various co-morbidities and incident depression, including cardiometabolic disease [16–18], overweight and obesity [

scale [40,41], AD8 dementia screening intervention [42–44], the Depression, Anxiety and Stress Scale (DASS-21) [45] and the MEDAS [46,47]. In this study, we used the Lawton's iADLs scale [40,41] and the AD8 dementia screening intervention [42–44] as potential confounders in our statistical analyses. The Lawton's iADL scale assesses an individual's functional capabilities for the following tasks: use of the telephone, food shopping and preparation, housekeeping, laundry, transportation, medication use and the ability to handle one's own finances. The AD8 dementia screening intervention was used to discern between normal cognitive status and signs and symptoms of dementia risk.

2.3. Symptoms of Depression, Anxiety and Stress

The DASS-21 was used to assess the severity of symptoms related to depression, anxiety and stress. This 21-item validated screening tool [48] comprises a set of three subscales (depression, anxiety and stress), each containing seven items where participants were asked to identify the presence of depression, anxiety or stress symptoms over the previous week. The depression subscale evaluates symptoms of low mood or loss of motivation; the anxiety subscale assesses symptoms of ongoing anxiety and worry; the stress subscale evaluates ongoing irritability and difficulty with unwinding. Responses to each statement were rated using a 4-point Likert scale with each item scored from 0 (did not apply to me) to 3 (applied to me very much or most of the time), with 0 indicating no presence of the symptom and 3 indicating that the symptom was present most of the time [45,49]. To identify the degree of severity for each of these emotional states, DASS-21 sub-scale severity ratings were calculated based on the original DASS-42 severity rating [49]. Specifically, each subscale was multiplied by 2 and divided into severity categories to yield equivalent scores for clinical purposes (Table 1) [49]. The DASS-21 has previously demonstrated positive psychometric properties when applied in older adults, demonstrating high convergent validity, acceptable discriminative validity and good-to-excellent internal consistency with a Cronbach alpha of 0.86–0.90 [50].

Table 1. Categorization of the severity of symptoms of depression, anxiety and stress derived from individual subscale scores identified with the DASS-21.

	Depression	Anxiety	Stress
Normal	0–9	0–7	0–14
Mild	10–13	8–9	15–18
Moderate	14–20	10–14	19–25
Severe	21–27	15–19	26–33
Extremely Severe	28	20	34

Abbreviations: DASS-21—Depression, Anxiety, Stress scale 21 items.

2.4. Mediterranean Diet Adherence

MedDiet adherence was evaluated using the 14-item MEDAS [47], which was developed and used in the PREDIMED study [46]. We have previously described the scoring and serve size and freq 0 m 392.8SeG 250(0.86 tency)u248(use)-29(259n)-risk.680(the)-609(scorin

Table 2. Serve size and frequency of consumption scoring criteria for the MEDAS.

MEDAS Questions	Criteria for 1 Point
Use of olive oil as the main source of fat when cooking?	Yes
How much olive oil do you consume per day?	Greater than 4 tablespoons (where 1 tablespoon = 15 g)
How many serves of vegetables per day?	Greater than 2 serves of vegetables per day (where 1 serve is equivalent to 2 cups vegetables)
How many pieces of fruit do you consume per day?	Greater than 3 pieces of fruit per day (this includes whole, tinned or dried fruit but excludes juice)
Serves of red meat per day?	Less than 1 serving of red meat per day (where 1 serve is equivalent to 100–150 g)
Serves of butter, margarine or cream per day?	Less than 1 serving of butter, margarine or cream per day (where 1 serve is equivalent to 10 g)
Serves of sugar-sweetened beverages per day?	Less than 250 mL of sugar-sweetened beverages per day
Red wine consumption per week?	Greater than 7 serves of red wine per week (where 1 serve is equivalent to 100 mL)
Serves of pulses/legumes per week?	Greater than 3 servings of legumes per week (where 1 serve is equivalent to 1 cup)
Servings of fish/seafood per week?	Greater than 3 servings of fish or seafood per week (where 1 serve is equivalent to 100–150 g)
Consumption of commercial pastries such as cookies or cake per week?	Less than 3 commercial sweets or pastries per week
Serves of nuts (including peanuts) per week?	Greater than 3 or more servings of nuts per week (where 1 serve is equivalent to 30 g)
Preferential consumption of white meat over red meat?	Yes
Frequency of consumption of vegetables, pasta, rice or other dishes with a sauce made with tomato, garlic, onion or leeks sautéed in olive oil?	Greater than 2 or more servings per week

2.5. Statistical Analysis

All continuous variables were presented as means standard deviation (SD), or median and interquartile ranges (IQR), with categorical data presented as frequencies and percentages. Independent samples t-tests were used to identify differences in demographic characteristics between genders. Multiple regression diagnostics were performed to ensure the basic assumptions of multicollinearity and homoscedasticity were not infringed. Multivariable linear regression analyses were used to investigate the independent association between adherence to a MedDiet (and the individual dietary constituents) on the severity of symptoms related to depression, anxiety and stress. In our regression analysis, we used covariates including age, gender, BMI, physical activity status, sleep duration, risk of cognitive impairment and ability to perform iADLs. Analyses were performed using the Statistical Package for the Social Sciences (SPSS) for Windows 27.0 software (IDM Corp., Armonk, NY, USA), with statistical significance set a $p < 0.05$.

3. Results

A total of $n = 303$ community-dwelling older Australians commenced the questionnaire; however, $n = 294$ participants (Females, $n = 201$; Males, $n = 91$; $n = 2$ unspecified) completed all components of the questionnaire, which was used in the final analysis. Demographic characteristics are reported in Table 3. Few participants self-reported a diagnosis of depression or anxiety (Depression: $n = 41$; 13.5%; Anxiety: $n = 5$; 1.7%). According to DASS-21 subscale scores, the total sample did not show 'greater than normal' symptoms of depression (6.0 (10.0); range: 0–40), anxiety (4.0 (8.0); range: 0–28) or stress (8.0 (10.0); range: 0–30). However, a total of $n = 99$ participants (33.7%) scored 'mild' or above for depressive symptoms in accordance with the DASS-21. A similar number of participants ($n = 80$; 27.2%) scored 'mild' or above for symptoms related to anxiety. By contrast, $n = 47$ participants (16%) scored 'mild' or greater for symptoms associated with stress. No significant differences for symptoms related to depression, anxiety or stress were observed between genders.

Table 3. Participant demographic characteristics by gender *.

Characteristics	Total	Male	Female
Age (years)	70.4 6.2	72 6.9	69.67 5.8
Gender *n*, %		96 (31.7)	205 (67.7)
BMI (kg/m^2)	28.8 7.2	29.1 8.7	28.8 6.5
Education status *n*, %			
No schooling completed	1 (0.3)	1 (0.3)	0 (0.0)
Junior or primary school	6 (2.0)	5 (5.2)	1 (0.5)
Secondary school	58 (19.1)	11 (11.5)	45 (22.0)
Trade/technical/vocational training	60 (19.8)	24 (25.0)	36 (17.6)
Diploma	56 (18.5)	18 (18.8)	38 (18.5)
Advanced diploma/associate degree	22 (7.3)	4 (4.2)	18 (8.8)
Bachelor's degree	54 (17.8)	18 (18.8)	36 (17.6)
Postgraduate degree or doctorate	45 (14.9)	15 (15.6)	30 (14.6)
Level of mobility *n*, %			
Independent without the use of any aids	279 (92.1)	87 (90.6)	190 (92.7)
Mostly dependent on a walking stick	15 (5.0)	8 (8.3)	7 (3.4)
Dependent on a four-wheeled walker	4 (1.4)	0 (0.0)	4 (2.0)
Dependent on a scooter	3 (1.0)	1 (1.0)	2 (1.0)
Services *n*, %			
No services, fully independent	268 (88.4)	83 (86.5)	183 (89.3)

Table 4. Univariable and multivariable linear regression coefficients expressing independent associations between adherence to a Mediterranean diet and the severity of depression, anxiety and stress symptoms.

Model	Depression		Anxiety		Stress	
	Beta	p	Beta	p	Beta	p
1 [a]	0.085 (0.768–0.114)	0.146	0.159 (0.901– 0.143)	0.007	0.173 (0.712– 0.145)	0.003
2 [b]	0.087 (0.786–0.117)	0.146	0.172 (0.949– 0.180)	0.004	0.178 (0.731– 0.150)	0.003
3 [c]	0.074 (0.749–0.180)	0.229	0.190 (1.016–0.028)	0.002	0.182 (0.752– 0.151)	0.003
4 [d]	0.076 (0.759–0.171)	0.214	0.189 (1.015– 0.223)	0.002	0.179 (0.748– 0.145)	0.004
5 [e]	0.049 (0.661–0.282)	0.430	0.171 (0.965– 0.160)	0.006	0.151 (0.680– 0.073)	0.015
6 [f]	0.000 (0.436–0.436)	1.000	0.119 (0.762– 0.021)	0.038	0.102 (0.537–0.025)	0.074
7 [g]	0.008 (0.411–0.472)	0.892	0.118 (0.761– 0.012)	0.043	0.080 (0.479–0.079)	0.159

Abbreviations: Beta, Standard beta coefficient; Standardised beta coefficient represents the change in a SD-unit increase in the Mediterranean Diet Adherence Screener score per change in outcome measure; Depression, Anxiety, Stress scale 21 items. [a] Non-adjusted model. [b] Adjusted for age and gender. [c] Adjusted for age, gender and Body Mass Index (BMI). [d] Adjusted for age, gender, BMI and average physical activity duration/day. [e] Adjusted for age, gender, BMI, average physical activity duration/day and average sleep duration/night. [f] Adjusted for age, gender, BMI, average physical activity duration/day, average sleep duration/night and cognitive risk (AD8 dementia screening intervention). [g] Adjusted for age, gender, BMI, average physical activity duration/day, average sleep duration/night, cognitive risk (AD8 dementia screening intervention) and ability to perform Instrumental Activities of Daily Living.

When we assessed individual dietary components of the MEDAS, increased vegetable intake was inversely associated with depressive symptoms, independent of age, gender, BMI, physical activity and sleep duration (= 0.117; CI: 4.069, 0.063; *p* = 0.043). Nevertheless, significance was lost after adjusting for cognitive risk. Furthermore, fruit intake was inversely associated with symptoms of stress, independent of all covariates used in the fully adjusted model (= 0.119; CI: 3.537, 0.133; *p* = 0.035). We also showed that nut consumption was inversely associated with both stress and anxiety symptoms independent of age, gender, BMI, physical activity and sleep duration (stress: = 0.180; CI: 4.145, 0.789; *p* = 0.004; anxiety: = 0.159; CI: 2.901, 0.392; *p* = 0.010). However, these findings were no longer significant after we adjusted for cognitive risk. We also observed an inverse relationship between legume intake and the severity of anxiety symptoms (= 0.133; CI: 3.210, 0.199; *p* = 0.027). Nevertheless, significance was lost after adjusting for cognitive risk. Lastly, a low consumption of sugar-sweetened beverages was inversely associated with symptoms of anxiety, independent of all covariates used in the fully adjusted model (= 0.136; CI: 2.897, 0.361; *p* = 0.012). No other significant findings for any other individual dietary constituent included in the MEDAS were observed.

4. Discussion

We explored the independent associations between adherence to a MedDiet and severity of symptoms related to depression, anxiety and stress in older adults. We showed that adherence to a MedDiet was inversely associated with severity of symptoms related to anxiety and stress. However, adherence to a MedDiet was not related to depressive symptoms. In addition, we showed that certain individual dietary elements of a MedDiet, including fruit, nuts, legumes and a low consumption of sugar-sweetened beverages (<250mL per day) were inversely associated with the severity of symptoms related to

vegetable intake, as defined by the MEDAS, was inversely associated with symptoms of depression, and fruit intake was inversely associated with stress-related symptoms. In addition, there is mounting evidence to support reciprocal pathways between the upregulation of pro-inflammatory cytokines and mood disturbances [66–69]. There is now evidence emerging that this may indeed be mediated by changes to the gut microbiota [70,71]. We also observed that the increased intake of nuts and legumes, as defined by the MEDAS, was inversely associated with the severity of symptoms related to anxiety. Both nuts and legumes, which are key dietary constituents of a MedDiet, are rich in dietary fibre, unsaturated fatty acids and bioactive compounds (e.g., antioxidants and polyphenols), which elicit a favourable prebiotic effect on the gut microbiota composition and metabolite production [72]. Lastly, sugar-sweetened beverages, the hallmark of a Western dietary pattern, are associated with a number of poor health outcomes, including depression and anxiety [73], and have been shown to cause unfavourable changes to the composition and function of the gut microbiota [74]. In this study, we observed that the low consumption of sugar-sweetened beverages (<250 mL per day) was inversely associated with symptoms of anxiety. Although we observed no relationship between MedDiet adherence and depressive symptoms, this may be due to the focus of our study being on older adults, where the literature has been inconsistent. As such, a Mediterranean-style diet should be promoted to support healthy ageing due to its efficacy on reducing the risks associated with multiple chronic diseases, including depression and associated disorders [75]. Nevertheless, further prospective studies and robust clinical trials with adequate samples, particularly in older adults with established q

dietary components of a MedDiet, including a low consumption of sugar-sweetened beverages as well as increased fruit, nut and legume consumption were all66 775depe5dentlyed

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