

NEW  
HYPOTHESES

# Exploring the association between anorexia nervosa and geographical latitude

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**ABSTRACT: Objective:** *This paper explores the relationship between anorexia nervosa (AN) and climate by mapping the distribution of references of AN in the literature at different latitudes. Method:* *The distributions of the bibliographic references of two medical disorders -psoriasis and cataracts-, and four mental disorders -AN, anxiety disorders, seasonal affective disorders, and schizophrenia- were mapped according to the institutional affiliation of their first author. Results:* *The distribution of references to AN was quite similar to the mental and medical disorders associated to high latitudes, although references to AN were more frequent in the range of 40°-55° in the Northern Hemisphere. Discussion:* *The psychosocial and sociocultural features of 'cultures' do not exhaust the factors defining the environment in which we live. Our findings indicate that climatic parameters, such as latitude may be a relevant factor in the occurrence of AN.*

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## INTRODUCTION

In spite of the ongoing compiling of data, the mapping of the global risk of anorexia nervosa (AN) is far from complete due to the lack of epidemiological data from non-western cultures (1). Moreover, the hypothesis that the risk of AN is increased by the idealization of thinness associated to western cultures (2), has not been supported by two recent reports from studies performed on newly affluent societies (3), or from urban populations from non-western countries increasingly exposed to western ways of life (4). These results undermine the view of AN as a purely culture-bound syndrome (5) or a culture-reactive syndrome (6), a perspective grounded more on unsupported assumption than on empirical findings.

The emphasis on the role of psychosocial and sociocultural factors and their impact on the risk of AN has obscured the role of environmental factors such as geographical latitude and temperature on AN. To our knowledge, only one study has addressed the association between AN and latitude i.e., a comparison of admissions to five hospitals located between 50° to 65°N in Sweden (7). Though the findings did not support an association, it should be borne

in mind that the results were obtained from a narrow range of latitudes within the same climatic zone.

We hypothesize that the association between AN and latitude may be linked to temperature, a factor closely tied to latitude. Latitude influences the seasonal range in solar intensity and is therefore coordinated with the distribution of temperature across the earth's surface. Latitude is the main factor that determines a region's climate, although within a given geographical zone other factors, such as altitude, proximity to the coastline and the influence of the oceanic stream are also key factors.

The incidence of other disorders, both medical and mental, has been reported to be related to latitude e.g., seasonal affective disorders (SAD)(8). SAD is endemic at high latitudes in the northern hemisphere during the winter season as a result of the reduced hours of sunlight. Although there is a summer variant of SAD linked to sun hours, it is much less frequent than the winter SAD. Moreover, latitude has also been reported to influence certain medical disorders such as cataracts (CAT) (9), and psoriasis (PSOR) (10) though the occurrence of these disorders is mainly determined by age or genetic predisposition.

Our hypothesis on the relationship

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between AN and latitude is drawn from two sources: (a) the experimental findings of the modulating role of ambient temperature in an animal model analogous of AN (11-13); and (b) clinical evidence suggesting that the external application of heat to humans affected by AN appears to benefit recovery (14-17).

The major obstacle that hinders the testing of the hypothesis of a relationship between AN and latitude is the absence of epidemiological data obtained in a broad range of the world's latitudes. Most epidemiological studies have been undertaken on populations between 40° and 65° latitude in the northern hemisphere (18). Thus, the available epidemiological data have been obtained from populations in temperate climates, with only a few reports from tropical countries.

Given the absence of suitable data on a worldwide scale, the geographical distribution of references to AN in the literature according to the institutional affiliation of the first author were mapped according to the latitudinal location in order to test our hypothesis. The underlying assumption is that the geographical distribution of the literature of a disorder will parallel the prevalence of the disorder. Bearing in mind that the allocation of funds and resources underlying health care services and the support of associated scientific activity is strongly influenced by political decision-making that usually justifies expenditures based on the needs of the local community, it is plausible to believe that the incidence of the disorder should be reflected in the geographical distribution of scientific publications. Thus, we postulate that scientific activity develops in relation to the site of the occurrence of the disorder and that the availability of patients and treatment facilities will increase the production of related scientific literature.

Though bibliometrics is a research method that has traditionally been used for the statistical analysis of the production of scientific literature, co-citation, and the influence of authors in a given field of research (19) to our knowledge, author affiliation has never been used as an indicator of the prevalence of a disorder. Nonetheless, bibliometrics can be a useful tool for testing new hypothesis and contribute to the generation of knowledge.

Thus, the purpose our study is twofold. First, to test the assumption that references for a disorder fit the differential geographical distribution of a particular disorder and are not evenly scattered around the world. Second, to test the hypothesis that AN is associated to latitude.

## METHOD

The methods used in this exploratory research are essentially identical to those used in bibliometric topic and author citation tracing.

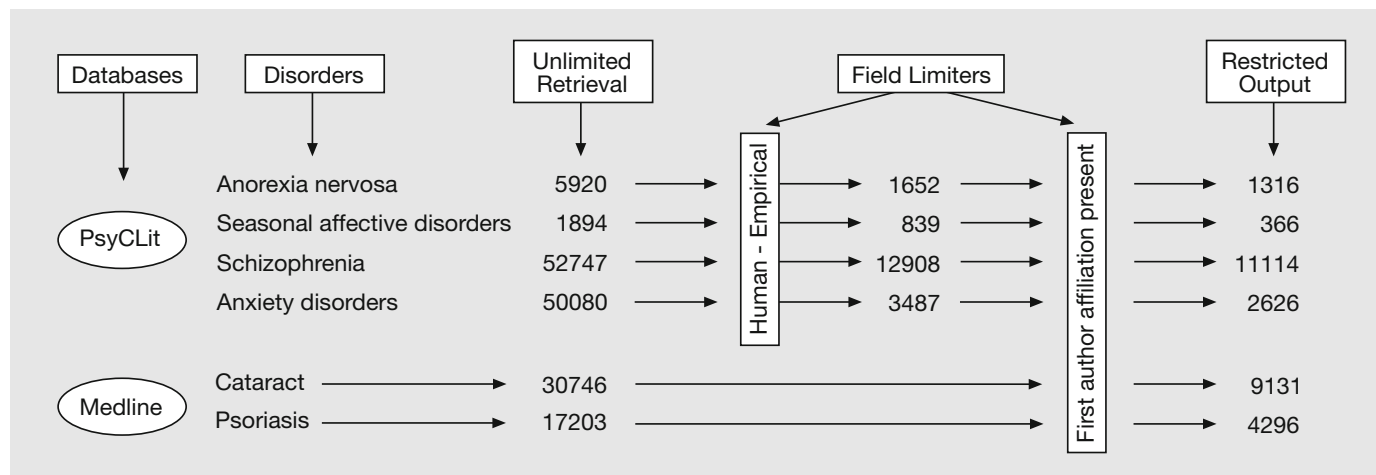
In order to test the plausibility of the assumption that the geographical distribution of references for a disorder parallels the geographical distribution of the disorder, the worldwide distribution of references for two medical disorders i.e., PSOR and CAT, and a mental disorder, SAD, which are known to be associated to particular latitudes, were mapped according to latitude. Thereafter, the relationship between AN and latitude was cross-checked by comparing the distribution of references for AN with those of the previously mentioned latitude-bound disorders, as well as with the distribution of references of two mental disorders for which there are no reports of any association to latitude i.e., schizophrenia (SCHIZ), and anxiety disorders (ANX).

In line with our hypothesis it is predicted that: a) there will be more citations for PSOR than for CAT at higher latitudes; b) there will be more citations for SAD than for ANX and SCHIZ at higher latitudes; c) if AN is associated to latitude, its distribution will be similar to that of SAD and PSOR, and will differ from CAT, ANX and SCHIZ, whereas the distribution of references to ANX and SCHIZ will be similar across latitudes.

### *Data collection*

For the purposes of this study, a search of both the Medline and PsycLit databases was undertaken to retrieve references for the six disorders under study during the last decade of the 20th century (from 1990 to 1999, inclusive). References to PSOR and CAT were retrieved from Medline, a database specialized in medical literature. References to four mental disorders; AN, ANX, SCHIZ, and SAD were retrieved from PsycLit. To avoid the selection of references of theoretical papers, the search was limited to the references qualified as 'empirical study' in the 'Form/Content Type' menu of PsycLit. It is plausible to believe that a non-limited search would include in the output many theoretical papers that could contaminate the supposed association of a given reference with latitude. It should be noted that the inclusion of the limiting field 'empirical' only ensured that a given reference was not entirely a theoretical contribution.

A further screening of the references was carried out by introducing the field 'Human' in the 'Population Group' menu in the data retrieval of the PsycLit databases. As shown in Figure 1, the introduction of these field limiters



**FIGURE 1**  
 Process of retrieval and selection of references.

reduced approximately 28% of the initial references for AN (from 5920 to 1652); from 1894 to 839 (44.3%) for SAD; from 10,080 to 3487 (34.6%) for ANX; and from 52747 to 12908 (24.5%) for SCH. Further screening with limiters in the PsycLit search menu such as 'experimental', 'case study', 'double-blind', and 'randomized' would have reduced the output to the extent that it would have made any statistical analysis impractical.

As for the retrieval of references from the PSOR and CAT, we were unable to further narrow down the output with the same field limiters on the Medline database. Only references that had institutional address information for the first author were considered.

The percentage of the psychiatric disorder references that remained after the above limits were applied to PsycLit were: 1316 (80%) AN; 366 (44%) SAD; 2626 (75%) ANX; and 11114

(86%) SCHIZ. Medline references enclosing first author affiliation were 4269 (25%) for PSOR, and 9131 (30%) for CAT. Thus, the PsycLit database permitted identification of the first author affiliation more frequently than Medline. However, the percentage of retrieved references for PSOR and CAT were similar, and the totals were large enough for statistical analysis.

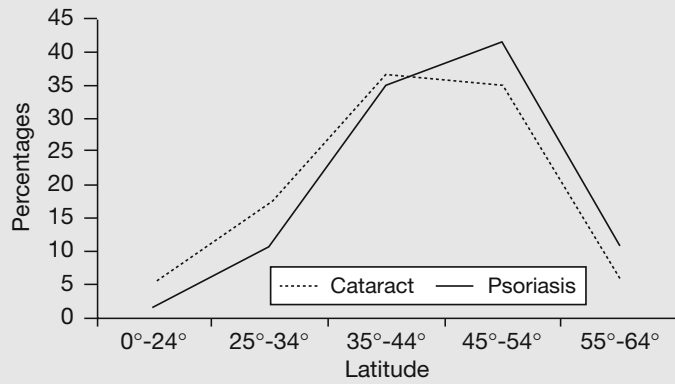
The procedure described above identified a total of 28,824 references, and their latitude was located using two computer assisted search engines on the Internet: <http://www.census.gov/cgi-bin/gazetteer>, and <http://worldatlas.com/geoquiz/thelist.htm>

*Data analysis*

References for each disorder were mapped according to their global location into northern (NH), and southern hemisphere (SH). Detailed

**TABLE 1**  
 Geographical distribution of references according to world latitude bands.

	Cataracts	Psoriasis	A. nervosa	SAD	Anxiety D.	Schizophrenia
World	9131	4274	1316	367	2626	11118
North H.	8772 (96.1%)	4171 (97.6%)	1227 (93.2%)	357 (97.3%)	2467 (94%)	10688 (96.1%)
South H.	359 (3.9%)	103 (2.4%)	89 (6.8%)	10 (2.7%)	159 (6%)	430 (3.9%)
Tropics 24°S – 24° N	463 (5.1%)	79 (1.8%)	20 (1.5%)	6 (1.6%)	58 (2.2%)	233 (2.1%)
North H. ≥24° N	8379 (91.8%)	4109 (96.2%)	1210 (91.9%)	354 (96.5%)	2432 (92.6%)	10501 (94.4%)
South H. ≥ 24° S	289 (3.2%)	86 (2%)	86 (6.5%)	7 (1.9%)	136 (5.2%)	380 (3.5%)



**FIGURE 2**  
Distribution of references in the North Hemisphere for cataracts (CAT) and psoriasis (PSOR).

analysis was performed by further subdividing the globe into three major latitude bands (NH $\geq$ 24°N; Tropics, 23° S to 23° N; and SH  $\leq$ 24°S); finally the entire NH was subdivided into five zones: 0°-24°, 25°-34°, 35°-44°, 45°-54°, and 55°-64°, whereas no subdivision was undertaken of the SH due to the scarce number of references. The frequency of references for each zone and disorder were counted and their corresponding percentages determined.

Given the exploratory nature of our study, nonparametric statistical analyses were performed using chi square analysis and differences between percentages among disorders for the latitude bands and zones were calculated. Due to the large number of references for some disorders only analysis yielding significant differences beyond  $p=0.001$  level were reported.

## RESULTS

The vast majority (over 95%) of the references for the six disorders were located in the NH (Table 1) whereas references from the SH were scarce.

Furthermore, the mapping of the SH revealed a disproportionate number of references from Australia and New Zealand (53% for PSOR, 76% for CAT, 77% for SCHIZ, 80% for SAD and ANX, and 85% in the case of AN). The remaining references from the SH were from geographically scattered in South Africa, South America and South Asia, most of them from the Equator to the Tropic of Capricorn (23° 27' S). Due to this irregular pattern, the distribution of references from both tropical zones i.e., NH (0°-23° N), and the SH (0°-23° S) were merged together into a common category i.e., the Tropics, which encompassed the references from Tropic of Cancer to the Tropic of Capricorn. The remaining references to NH over parallel 24° (NH $\geq$ 24°N), and SH below parallel 23° (SH $\leq$  24°S) are shown in the two bottom rows of Table 1.

The comparison of the distribution of references for CAT and PSOR in the NH ( $\geq$ 24°N), SH ( $\leq$  24°S), and Tropics (23°S - 23°N) revealed significant difference (chi square= 94.6, gl, 2;  $p<0.0001$ ), which were mainly due to the greater percentages for CAT references from the tropical zone ( $p<0001$ ) (Table 1).

As for the NH, Figure 2 illustrates the distribution of references in the NH including all the references from the Equator to latitude 64° N. The distribution of references of PSOR was displaced to the right with respect to CAT.

**TABLE 2**  
Geographical distribution of references for Northern Hemisphere (\*).  
(From the Equator to latitude 64° N).

	Cataracts	Psoriasis	A. Nervosa	SAD	Anxiety D.	Schizophrenia
0°-24°	484 (5.52%)	65 (1.57%)	18 (1.47%)	3 (0.85%)	40 (1.62%)	202 (1.89%)
25°-34°	1508 (17.19%)	455 (10.97%)	131 (10.7%)	23 (6.53%)	327 (13.26%)	1445 (13.52%)
35°-44°	3183 (36.29%)	1452 (35.%)	466 (38.%)	159 (45.17%)	1227 (49.74%)	4810 (45.02%)
45°-54°	3064 (34.93%)	1719 (41.43%)	542 (44.2%)	119 (33.81%)	738 (29.92%)	3344 (31.30%)
55°-64°	533 (6.08%)	458 (11.04%)	70 (5.7%)	48 (13.64%)	134 (5.43%)	859 (8.04%)
(#)	8772	4149	1227	352	2466	10660

(\* )Percentages with respect to total of references for the range 0°-64°, in the NH. (#)Totals here differ from those shown in the row 'North H' in Table 1 since there were no references counted above 64° N. SAD=Seasonal affective disorders.

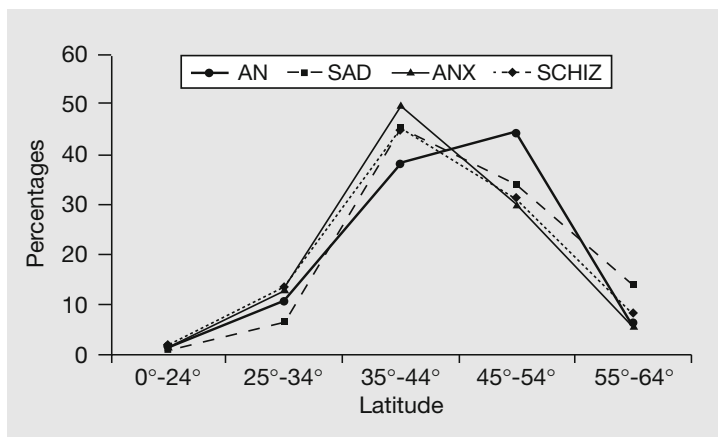


Significant differences ( $p < 0.00001$ ) in the percentages for each latitude zone were found, except for the intermediate latitude zone  $35^{\circ}$ - $44^{\circ}$  N (Table 2). This indicates that CAT references were three times higher than PSOR - 5.5% vs. 1.6% - in the tropical zone of the NH (range  $0^{\circ}$ - $24^{\circ}$ ), and twice those for PSOR - 22.7% vs. 11.6% - for the two first latitude zones ( $0$ - $24^{\circ}$ N,  $25^{\circ}$ - $34^{\circ}$  N). In contrast, the opposite occurred for higher latitudes ( $55^{\circ}$ - $64^{\circ}$  N), PSOR references almost doubled those for CAT (11% vs 6%), and the accumulated percentages for the two northern latitude zones ( $45^{\circ}$ - $54^{\circ}$  N,  $55^{\circ}$ - $64^{\circ}$  N) were much greater for PSOR (52.4,% vs. 41.9%). As for the intermediate latitude zone ( $35^{\circ}$ - $44^{\circ}$ ), the percentages were similar for both disorders (PSOR, 34,9%; CAT, 35%).

In short, CAT and PSOR references are differently distributed in latitudes across the world and in particular the NH, which is consistent with the acknowledgement of the latitude-bound nature of these disorders. This supports our assumption that the geographical location of references in the literature parallels the geographical distribution of a disorder.

As for the latitudinal distribution pattern of references to AN, Figure 3 shows the distribution of references for AN and the other three mental disorders. The AN distribution shows a displacement to the right, similar to the displacement of PSOR with respect to CAT in Figure 2. In fact, the PSOR percentages were only significantly different ( $p < 0.000001$ ) to the AN percentages at higher latitudes ( $54^{\circ}$ - $64^{\circ}$  N).

Similarly, SAD references predominated at higher latitude whereas SAD percentages (7.3%) at lower latitudes ( $0^{\circ}$ - $24^{\circ}$  /  $25^{\circ}$ -  $34^{\circ}$ ) were significantly lower than those for ANX (14.9%,  $p = 0.0001$ ), and SCHIZ (15.4%,  $p = 0.00003$ ). At higher latitudes ( $45^{\circ}$ - $54^{\circ}$  /  $55^{\circ}$ - $64^{\circ}$ ) SAD percentages (47.5%) were significantly higher than SCHIZ (39.3%,  $p < 0.001$ ), and ANX (35.5%,  $p = 0.00001$ ), but similar to AN (49.9%). Interestingly, in the  $45^{\circ}$ - $54^{\circ}$ N latitude zone, AN (44.2%) scored significantly higher than SAD (33.8%,  $p = 0.0005$ ), SCHIZ, (31,3%,  $p < 0.000000$ ), and ANX (29.9%,  $p < 0.000000$ ), whereas SAD scored the highest in the  $55^{\circ}$ - $65^{\circ}$  latitude range (13.6% vs. 8.4%, 5.7% and 5.4% for SCHIZ, AN and ANX, in all cases  $p < 0.0001$ ). These findings reveal that, similar to PSOR (11%), SAD was much more of a northern disorder than AN and, for that highest latitude zone  $55^{\circ}$ - $65^{\circ}$ , AN was similar to SCHIZ and ANX (8% vs. 5.7% and 5.4%, respectively). Therefore, AN was associated to moderately high latitudes ( $45^{\circ}$ -



**FIGURE 3**  
Distribution of references in the North Hemisphere for anorexia nervosa (AN), seasonal affective disorders (SAD), anxiety disorders (ANX) and schizophrenia (SCHIZ).

$54^{\circ}$ ), but not to the highest latitudes as was the case of SAD.

As shown in Table 1, half of the AN references in the NH were located above  $45^{\circ}$  NH. This percentage was quite similar to the two disorders associated to high latitudes in the NH (SAD, 47%; PSOR, 52%), and significantly greater ( $p < 0.000001$ ) than that obtained for the other two mental disorders, SCHIZ and ANX which were below forty percent (SCHIZ, 39%, and ANX, 35%) i.e., a percentage similar to CAT (40%) which is associated to lower latitudes. Further analysis revealed that 67% of the world references for AN were concentrated in the latitudes zone  $40^{\circ}$ - $55^{\circ}$  in the NH. This means that 72% of AN references in the NH were concentrated within a  $15^{\circ}$  latitude range ( $40$ - $55^{\circ}$ N), which is a percentage significantly greater than the 58.5% obtained for SAD, the 64.2% for ANX, and the 63.2% for SCHIZ ( $p < 0.000001$  for each comparison).

## DISCUSSION

The first reference to the relationship of AN and environmental temperature appeared in the editorial of 1888 (20) and was a commentary on the last paper published by W. Gull on AN (21), that appeared the preceding week in the said journal. The editorial stated: "Most of the cases seem to occur in the colder months of the year, and possibly this may be more than a coincidence". To paraphrase the editorial, we may say that the observed association between AN references and latitude in the NH may be more than a coincidence.

Moreover, the bibliometric profile of AN

references is coherent with the paucity of epidemiological studies performed under latitude 40° N. Furthermore, though the data on AN in tropical areas is scarce, the studies available underline the low incidence of AN. For example, three recent studies carried out in the Caribbean area reported a low incidence of AN. This is the case of the epidemiological study performed in Curaçao (12°N), which found "a low overall incidence rate of AN" (3), a finding which was contrary to what the authors had hypothesized (22). Moreover, all the AN diagnosed cases had lived for some time outside the latitude of Curaçao' island (23). Likewise, a study consisting of case records and a survey among health professionals in Jamaica (18°N) concluded that AN was quite rare (24). Similarly, a study in the Venezuelan city of Maracaibo (10°N) found no cases of AN in a sample of 1000 adolescents, aged nine to nineteen (25).

The low incidence of AN reported in these studies, together with our bibliometric findings are in line with the protective role of warmer environments which inhibit and revert self-starvation in an animal model analogous of AN, as well as underlining the beneficial role of heat in recovering from AN in human patients. The mechanism through which a benign climate, which is characteristic of tropical areas, protects against the development and maintenance of AN is related to the buffering effect of a warm environment over the deficit in body insulation due to weight loss. In the context of a cold environment, a loss of insulation jeopardizes thermoregulatory homeostasis which in turn triggers an increase in physical activity in order to produce heat as remedy for the ensuing hypothermia (9). The greater the increase in physical activity, the greater the likelihood that a) the inhibitory effect of activity on appetite will increase (26, 27); b) body insulation diminishes due to the dwindling of fat reserves; and c) further impairment of effective thermoregulatory homeostasis (11). Recently, the sharp increase in the activity levels of female adolescents approximately one year before the diagnosis of AN has been reported (28), which suggests that enhanced physical activity may play a precipitating role in the development of AN (11, 29, 30) The buffering effect of a warm environment may be critical in impeding the positive feedback loop between diet and activity.

An association between AN and environmental temperature has also been advanced to explain the apparent season of birth effect on AN, particularly in early-onset cases (31). Others have suggested the peak of births in

spring and early summer (32) may explain the intrauterine effect of common infectious agents during the winter months, in the second trimester of pregnancy (33). Alternatively, the season of birth effect has been associated to the role of environmental temperature on the fertility of AN' mothers. According to this "temperature at conception" hypothesis: "the relatively restrictive mothers of the AN children may have been more fertile during the warmer months of the year (July-September in the UK), due to the reduced need to divert physical resources towards retaining body temperature" (33).

The protective effect of a warm environment on body temperature may not only heighten fertility, but may protect their offspring from developing AN.

Our results are not consistent with a recent study on a non-clinical population which suggested that a warm climate may increase eating disorder pathologies (34). However, the authors compared the self-reported bulimic attitudes of university students from two different campuses (located in Florida and Pennsylvania), not eating disorder patients.

Notwithstanding, the exploratory nature of this preliminary bibliometric study cannot rule out alternative interpretations regarding the association between AN references and latitude i.e., AN references in certain latitudes could reflect demographic peculiarities such as a greater proportion of adolescent females in populations in a given latitude which may generate a great percentage of AN references; or that a specific latitude may be associated to other unknown risk factors; or that ethnic differences may play a role in the relationship between latitude and AN.

We are aware that the present study entails several limitations. First, the use of a bibliometric methodology to elucidate the link between AN and latitude, viz. environmental temperature may be tentative. Nevertheless, the contrast between PSOR and CAT renders plausible the use of first author affiliation as a likely indicator of the incidence of a disorder. Second, co-authorship and mobility of researchers are two threats to the assumption that the affiliation of the first author in the references to scientific activity retains any geographical distribution underlying a disorder. However, as these aspects -co-authorship and mobility- would run against the hypothesis, they would make the test more robust, (increasing the possibility of a Type II error) as both would introduce noise to the hypothesized signal i.e., the incidence of a disorder linked to latitude is reflected in the distribution of references.

In short, AN may be a culture-bound syndrome, but our findings underscore the need for exploring the association between latitude, climate and AN. Our results do not exclude culture-bound hypothesis (5, 6). Besides “culture”, other factors may operate in the environment where AN develops and this paper aims to explore new avenues in the understanding of the etiology of AN. When comparing samples of people exposed to a different culture with their peers in their home culture, environmental temperature or other climatic factors may act as unacknowledged artifacts on the presupposed effects of a pure acculturation processes.

It would be an error to think that a comparison between ‘cultures’ would exhaust the factors defining the environments in which we live, particularly in the face of a lack of a clear definition underlying terms such as ‘culture’ or the label ‘western’. The literature concerning cultural connection to AN is extensive and has primarily focused on the mental, cognitive and symbolic factors associated to AN. This paper provides a complementary perspective to the term ‘environment’ by encompassing other factors that have been overlooked and may influence AN. This study raise doubts concerning the predominant role of culture on AN, in line with other authors: ‘Social models of aspiration for thinness among western cultures as the single most important aetiological factor is not supported by the lack of rise in anorexia in non-western societies, and the geographical distribution of the disorder requires a rethink on the aetiology of the disorder’ (4).

To extend this preliminary study to a much larger scale of analysis may provide insight into the role of climatic factors on AN. The focus on climatic factors, however, does not undermine the role of cultural factors given that a very promising and fruitful area for future research could be the study of ‘cultural’ practices of high latitude cold climates, as is the case of ‘sauna culture’ in Finland, and their potential beneficial role on AN (35, 36). Further studies are required to elucidate the association between AN and latitude and may provide clues as to the manipulation of the environment for the treatment of patients suffering from AN, as can be seen from the recent reports of the beneficial role of external heat for the treatment of these patients (11-18).

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