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Rhegmatogenous Retinal Detachment and Solar Radiation in Northwestern Spain

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Keywords
Epidemiology · Incidence · Retinal detachment · Solar radiation · Seasonal variation · Spain

Abstract
Objective: The aim of this study was to investigate the association between rhegmatogenous retinal detachment (RRD) and solar radiation in northwestern Spain. ***Methods:*** All RRD cases in Pontevedra from 2008 and 2014 were retrospectively analyzed. Climatological data from 4 weather stations in the area were collected. The association between RRD incidence and solar radiation was investigated. ***Results:*** A total of 256 RRD cases were identified. There was a seasonal variation in the incidence of RRD with a maximum number of incident cases observed in June and July and a minimum number of cases observed in January and December. An association was found between RRD incidence and solar radiation both monthly ($p = 0.004$) and bimonthly ($p = 0.057$). The right eye was more frequently affected than the left eye ($p = 0.035$). RD cases other than rhegmatogenous showed neither seasonality nor association with radiation. ***Conclusions:*** Solar radiation may play a role in RRD genesis in our area. Laterality could be related to the amount of radiation reaching each eye.

Introduction

Rhegmatogenous retinal detachment (RRD) is one of the most frequent ophthalmological surgical emergencies with an annual incidence ranging from 7 to 22/100,000 inhabitants [1–4]. The main predisposing factor for the development of this pathology is a posterior vitreous detachment and debilitating disorders of the peripheral and equatorial retina such as lattice degeneration [1, 4–8], but environmental factors in general and climate factors in

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particular could also play a role as the seasonal variation observed in the incidence of this pathology suggests [1–3, 5, 6, 9–19].

With regard to the climatic or astronomical factors that might be associated with this seasonal variation, a number of studies have analyzed temperature, humidity, or atmospheric pressure, but their results are inconsistent [1–6, 9–18]. Regulatory mechanisms [20, 21] and the apparent impermeability of the eye to the effects of these variables might explain in part their discrepancies. In contrast to them, sunlight exposure has proven to negatively affect the anterior as well as the posterior segment of the eye [22, 23]. This variable has also been investigated in relation to RRD incidence, but the results of these investigations are inconclusive maybe because solar radiation and sunlight exposure, which is a surrogate variable for solar radiation, do not always correlate [24].

Based on the fact that solar radiation is one of the few climate variables that have demonstrated to cause pathology in the eye, we hypothesize that this pathologic effect might also be associated with the incidence of RRD and its seasonal variation. The confirmation of the potential effect of solar radiation on the incidence of RRD and how this and other factors behave and interplay in different populations would further our understanding of the factors influencing this disorder, promote awareness of this potentially blinding disorder, and help plan global prevention strategies. Having this in mind, we aimed to investigate the association between RRD incidence and the variation in solar radiation in our area.

Methods

This study was carried out in Pontevedra area, in northwestern Spain (42º north of the equator). This area covering 1,485 km^2 is divided into 25 municipalities and had a total population of 302,688 inhabitants when the study began (Fig. 1). The western or coastal zone that includes the most densely populated municipalities has a Csb-Köppen oceanic climate with mild summers, a mean annual rainfall of up to 1,600 L/m^2, and an average yearly temperature of around 15ºC, whereas the inland zone has a Csa-Köppen transitional oceanic climate, with hot summers, a mean annual rainfall of up to 1,300 L/m^2, and an average yearly temperature of around 12ºC (source: climate-data.org). The mean and maximum altitudes are 162.7 and 1,017 m, respectively.

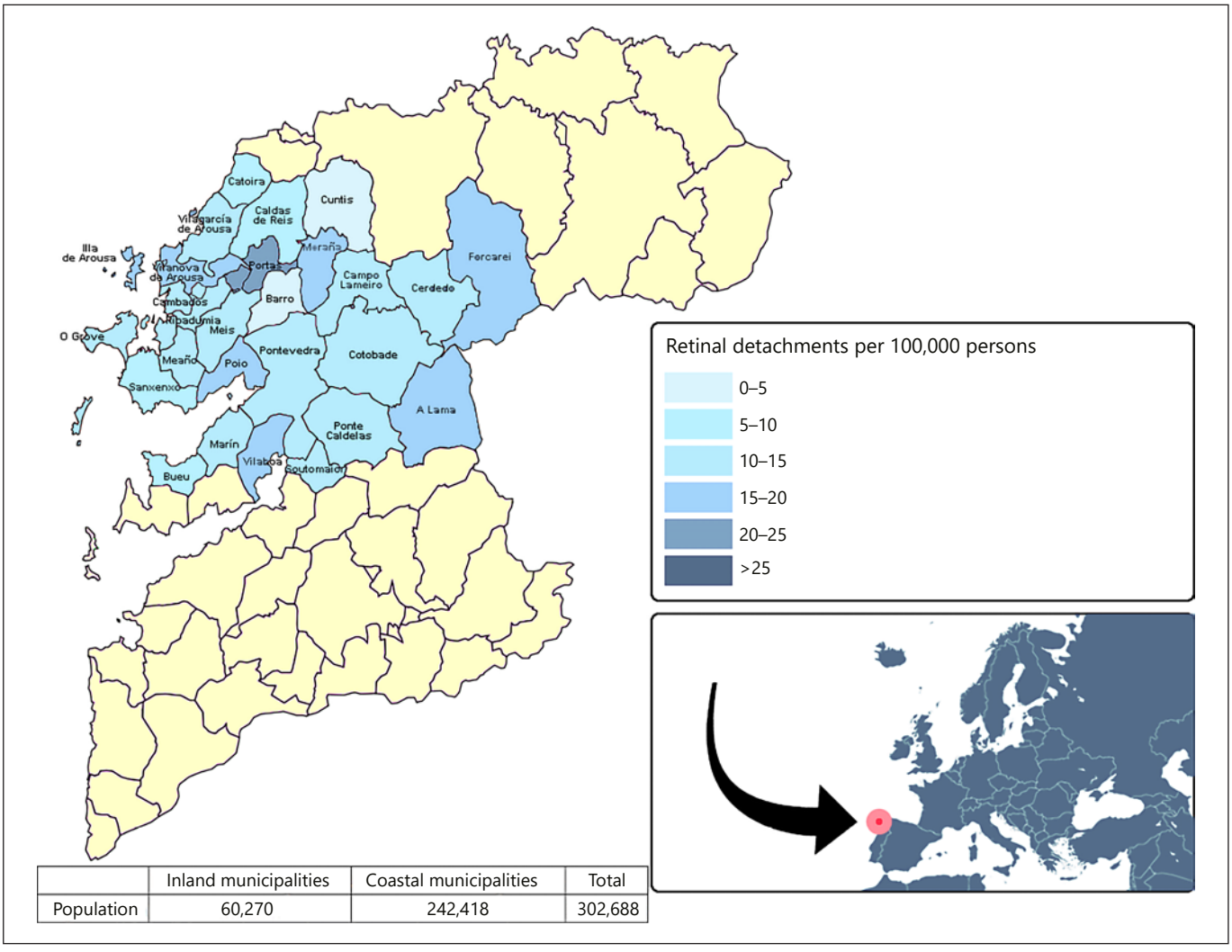
Our hospital was virtually the only one providing vitreoretinal surgery during the study period. RRD was defined as an accumulation of subretinal fluid of at least 2 disc diameters in size associated with one or more full-thickness retinal breaks detected during the preoperative examination or during the surgical procedure. RRD patients who had had surgery between 2008 and 2014 were identified from surgical logbooks. The medical records of all these patients were reviewed. Emergency records were also checked to identify patients who for any reason had not had surgery. Data extracted included demographic and clinical information such as the age and sex of the patients, date of diagnosis and surgery, and time elapsed between the onset of symptoms and the time of diagnosis. Only those patients residing in the area at the time of diagnosis were included in the study. Chronic RRD and non-RRD cases were excluded from the analyses. Recurrent cases and subclinical RRD that could be treated by laser were also excluded.

Monthly solar radiation was defined as the mean daily incident solar radiation for each month. Solar radiation data were obtained and averaged from the 4 meteorological stations (Lourizán, Rodeiro, Fornelos, and Corón) across the area. The association between the incidence of RRD and solar radiation was calculated based on the Poisson distribution. To analyze this diachronic association, the Pearson correlation coefficient as well as the Spearman test were used. Laterality comparing the left and right eye was analyzed with the χ^2 test. Statistical analyses were carried out using the R language for statistical computing 2017 statistical package [25].

Results

From 360 RD cases, a total of 256 patients with the rhegmatogenous type of detachment, all of them Spanish Caucasians, were identified from a population of 302,688 people. Solar radiation did not vary significantly over the study period (Fig. 2). The monthly and bimonthly mean number of RRD cases and corresponding monthly and bimonthly mean solar radiation are presented in Figures 3 and 4. The maximum number of incident cases were observed in June (n = 25) and July (n = 25), which were the months of maximum mean radiation exposure. The minimum number of cases was recorded in November (n = 10), which was the third month of minimum radiation exposure.

There was a correlation between solar variation and the incidence of RRD both monthly (r = 0.754; p = 0.004) and bimonthly (r = 0.797; p = 0.057) using the Pearson correlation coefficient. Using the Spearman test, correlation was also positive monthly (r = 0.66) and bimonthly (r = 0.83). Regression analysis of the same period for solar radiation and RRD incident cases as independent and dependent variables, respectively, is presented in Figure 5. Linear correlation was confirmed monthly (R^2 = 0.57; p = 0.005) and bimonthly (R^2 = 0.63; p = 0.06). Analyses using accumulated solar radiation instead of mean solar radiation rendered similar results (data not shown). Right eyes were more frequently affected than left eyes (46.6%; p = 0.035). RD cases other than rhegmatogenous showed neither seasonality nor association with radiation.



	Inland municipalities	Coastal municipalities	Total
Population	60,270	242,418	302,688

Color version available online

Fig. 1. Geographical distribution of RRD in our area, by municipalities.

Discussion

The main finding of this study was that increases in solar radiation intensity were associated with increases in the incidence of RRD. In our study, a greater number of RRD was observed at the end of spring and in summer: this coincides with numerous previously published articles [1–6, 9–19] (Table 1). This association was not completely linear as the months of the lowest radiation intensity, namely, January and December, were not the months with less incident cases. It is conceivable that solar radiation might be a contributing factor for the development of a posterior vitreous detachment and a possible RRD. The lower incidence rates in months of medium radiation could be explained by the depletion of potential cases, earlier. Jonkers [9] and Weekers [10] observed an association between the seasonal variation of the incidence of RRD and sun exposure, but Belmonte and Rezola [18], in a study performed in Spain, did not. The fact that sun exposure does not always correlate with solar radiation [24] and that there may be influencing factors other than solar radiation may explain this lack of agreement. Solar radiation may thus be a predisposing factor, although not the only one, for the development of this disorder, as these studies seem to suggest.

The tendency to close the nondominant eye in strong sunlight [26] and consequently reducing the amount of light entering into it may explain why the right eye was more frequently affected than the left one in this study and in others and also supports the idea that solar radia-

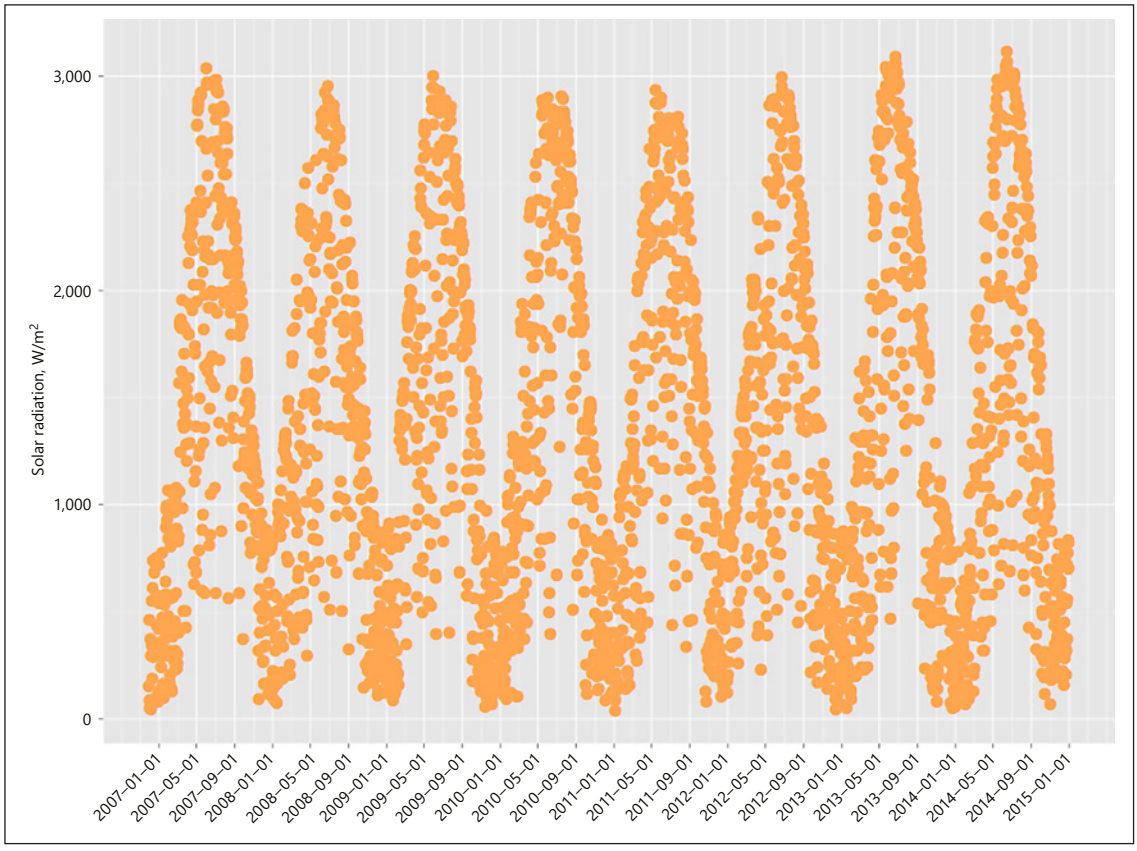


Fig. 2. Mean solar radiation recordings from 2008 through 2014.

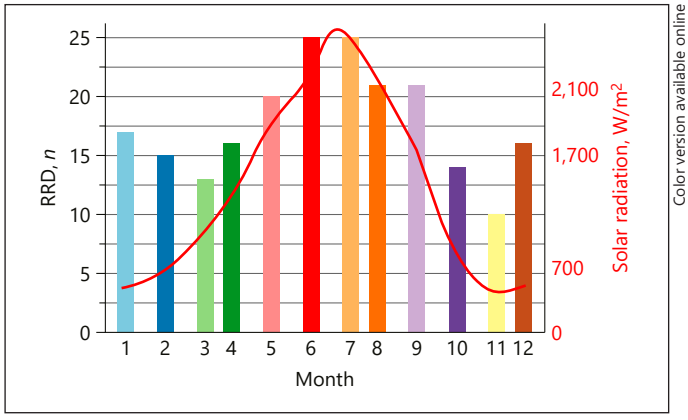


Fig. 3. Averaged monthly RRD cases and averaged monthly solar radiation.

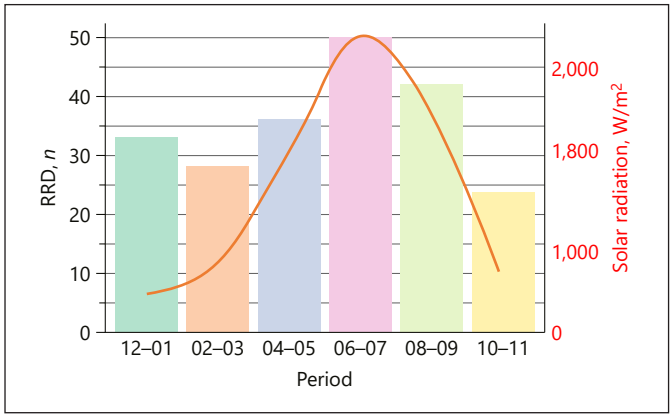


Fig. 4. Averaged bimonthly RRD cases and averaged bimonthly solar radiation.

tion may be responsible for the seasonality of RRD, since the majority of the population is right-eye dominant [27]. Basic investigation provides evidence in this regard. Several studies have found that ultraviolet radiation increases catalase activity and the formation of free radicals in the vitreous in animal models [28, 29]. The molecular changes in the retinal pigment epithelium and in the vitreous brought about by these events would decrease the adherence function of the retinal pigment epithelium

Table 1. Association between climate factors and RRD in incidence studies

First author [ref.]	Year	Country	Design	Sample size	Months	Association
Weekers [10]	1945	Belgium			Jun–Aug	
Jonkers [9]	1952	Netherlands		836	Mar, Jun	Light intensity
Gärtner [16]	1977	Germany		771	Jun–Aug	Cortisol?
Paavola [14]	1983	Finland				
Belmonte [18]	1982	Spain	Retrospective	380	Apr	No association with light, T
Laatikainen [1]	1985	Finland	Retrospective	310	Aug–Sep	
Ghisolfi [12]	1986	Italy	Prospective	363	Jul–Aug	Light, radiation
Al Samarrai [11]	1990	Kuwait	Cohorts	266	Jan–Feb	Inverse association with light and T
Thelen [3]	1997	Germany	Retrospective	2,314	Jul–Aug	
Ivanisević [19]	2002	Croatia	Retrospective	280	Summer	No association with sunlight exposure
Mansour [5]	2009	Lebanon	Retrospective	211	Jul–Aug	
Bertelmann [13]	2011	Germany	Retrospective	2,605		Solar radiation
Lin [2]	2011	Taiwan	Retrospective	23,718	Jul–Aug	T, atmospheric pressure
Prabhu [6]	2016	India	Retrospective	76	Mar–May	T, humidity, rain
Manners [15]	2017	Australia	Prospective	4,376	Spring	
Auger [17]	2017	Canada	Retrospective	14,302		T
This study		Spain	Retrospective	256	Jun–Jul	Solar radiation

T, temperature.

[12], promote vitreous liquefaction [6], and facilitate the formation of a posterior vitreous detachment that could eventually, as mentioned before, cause a retinal break and a possible RD [9, 10, 12–14]. The seasonal changes in plasma cortisol [16] and vitamin A [30, 31] levels induced by sunlight may also contribute to this vitreous degradation. Ghisolfi et al. [12] go on as far as to say that "solar radiation acts the same way as an ocular contusion" to explain the multiple effects of solar radiation potentially leading to a RRD.

Another factor supporting the fact that solar radiation may be an important factor is that the incidence of RRD is much lower (0.46/100,000 inhabitants) [7] in black people [32], while there are no differences in the number of holes or the percentage of vitreous detachments, suggesting stronger adherence in their retinal pigmentary epithelium [32]. We argue that as black subjects present higher levels of melanin, they have greater resistance against solar radiation, in the same way that they present a lower incidence of non-melanoma skin cancer [33] due to this protective factor. Similarly, there is a lower risk of RRD in very dark-colored iris [8] subjects, possibly due to the same reason, as a smaller amount of solar radiation is able to enter the eye.

Other climate factors that have been studied in previous studies (Table 1) include temperature [5, 6, 11, 13, 17, 18], humidity [2, 5, 6, 12, 13, 18], rain [2, 5, 6, 12, 13], sunlight exposure [19], daylight hours [4, 5, 12], fog, or wind [12, 13]. Some of these variables are related to a greater or lesser extent to solar radiation, but those that are not so clearly associated have not been proven, in contrast to solar radiation, to being capable of easily overcoming the regulatory mechanisms and physical barriers of the eye. This is prob-

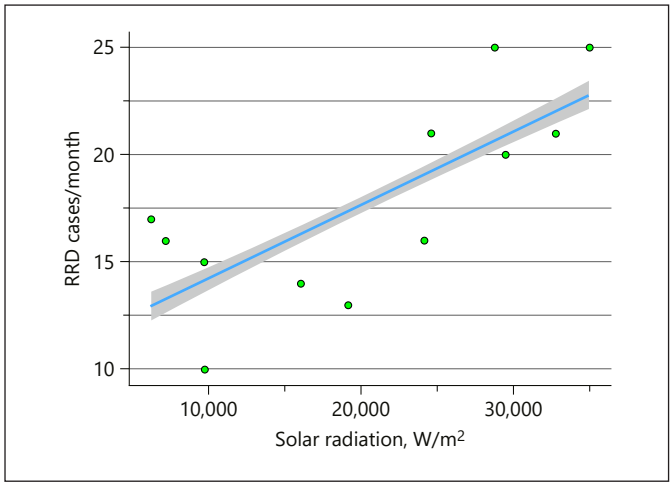


Fig. 5. Correlation between averaged monthly RRD incident cases and averaged monthly solar radiation.

ably one of the reasons why these investigations provide inconsistent and sometimes contradictory results.

We defined monthly mean solar radiation as the mean daily solar radiation for each month. Averaging monthly mean solar radiation increased the power of the analyses as this value was similar for the same month over the whole study period (Fig. 2). The differences between the recordings of the climate stations were minimal, and the longest distance from them was 27 km. Solar radiation data were averaged to give global results. However, our analyses might have been biased by the number of patients who for several reasons such as lack of trust could have sought medical attention in another hospital. The fact that ours was the only hospital in the area providing vitreoretinal surgery during the study period, and the high level of satisfaction of the patients with the ophthalmology department revealed in periodic surveys minimizes this. The size of the sample and the potential sources of bias of retrospective designs are also limitations of the study.

In summary, in this study, the incidence of RRD showed a seasonal variation that was associated with variations in solar radiation. This radiation also seemed responsible for the greater susceptibility of the right eye to this pathology. Further research is needed to broaden our understanding of the factors associated with the seasonal variation of the incidence of RRD and their relationship with solar radiation.

Conclusions

We found a greater number of RRD cases in the summer months, and a statistical relation with solar radiation. Thus, it is possible that solar radiation could be a predisposing factor for RRD genesis in our environment.

The right eye is more frequently involved than the left one. It could be due to the greater solar exposition of the dominant eye, giving more weight to the former hypothesis.

Statement of Ethics

This study was approved by the Galician Ethics Committee. The study conformed to the principles of the Helsinki Declaration and was reviewed and approved by the Regional Research and Ethics Committee.

Disclosure Statement

The authors declare no conflicts of interest.

Funding Sources

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