**Title**: Physical activity, seasonal sensitivity and psychological well-being of people living in extreme climates.

**Authors**: Caren Alvarado1,2, Matías Castillo-Aguilar2,3,Valeska Villegas2, Claudia Estrada Goic3, Katherine Harris2,3, Patricio Barria4,5, Michele M Moraes6,7, Thiago T Mendes8, Rosa ME Arantes6,7, Cristian Núñez-Espinosa1,2,9\*

1 School of Medicine, Magallanes University, Punta Arenas, Chile.

2 Centro Asistencial de Docencia e Investigación (CADI-UMAG), Punta Arenas Chile.

3 Kinesiology department, Magallanes University, Punta Arenas, Chile.

3 Psychology department, Magallanes University, Punta Arenas, Chile.

4 Corporación de Rehabilitación Club de Leones Cruz del Sur, Punta Arenas, Chile.

5 Brain-Machine Interface Systems Lab, Universidad Miguel Hernández de Elche, Elche, España.

6 Department of Pathology, Institute of Biological Sciences, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil.

7Associate researcher of the Center for Newborn Screening and Genetics Diagnosis, Faculty of Medicine, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil (NUPAD-FM/UFMG).

8 Department of Physical Education, Faculty of Education, Universidade Federal da Bahia, Salvador, BA, Brazil.

9 Interuniversity Center for Healthy Aging, Chile.

### \*Autor de correspondencia

Cristian Núñez-Espinosa, School of Medicine, Magallanes University, Punta Arenas, Chile. Centro Asistencial de Docencia e Investigación CADI-UMAG, Chile. e-mail: [cristian.nunez@umag.cl](mailto:cristian.nunez@umag.cl). Address: Avenida Bulnes 01855, Box 113-D. Phone: +56 61 2201411.

## Abstract

**Introduction:** Physical activity can prevent a large number of organic and mental pathologies. Outdoor activities have greater benefits than indoor activities; however, fluctuations in climatic conditions may affect these practices, altering psychological well-being and favouring the prevalence of seasonal sensitivity (SS). **Objective:** to determine the relationships between the practice of physical activity, seasonal sensitivity and well-being in people living in high southern latitude. **Material and methods:** the Seasonal Pattern Assessment Questionnaire (SPAQ), Psychological well-being scale was applied, and sports practice was determined according to the recommendations of the World Health Organization (WHO) in 358 participants, men (n=197; 55%) and women (n=161; 45%). **Results:** 194 people reported physical activity. There was a significant lower proportion of people with SS high-intensity physical activity practitioners compared to…. In terms of psychological well-being, an adverse effect was found between the Seasonal Score Index (SSI) and five subcateographies of the Ryff well-being scale. **Conclusion:** Those who perform high-intensity physical activity have lower SS, and those who have higher SS have lower psychological well-being.

**Keywords**: Physical Activity, Seasonal Affective Disorder, Mental Health, Extreme Weather.

# Introduction

Seasonal changes in natural light that affect high southern latitude areas can condition the mood of the people living there, leading to what is known as “seasonal sensitivity” (SS). This condition is the sensitivity of individuals to seasonal variations which related to the time of exposure to sunlight (increased during the summer and decreased during the winter)(1), leading to a disorder characterized by hypersomnia, increased carbohydrate appetite, weight gain and extreme fatigue (2,3). Physiologically, these changes can induce disruptions in the circadian cycle and neuroendocrine dysregulation (e.g., melatonin, which is directly related to sleep disturbances, and serotonin, which is related to depressive symptoms) (4–6). The autonomic dysregulation and consequent variations in vagal tone and alterations in cardiac regulation in the face of stress, can lead to an increased risk of cardiovascular disease (7,8). These physiological effects, associated with psycho-social adaptation, can affect mental health, where higher levels of anxious and depressive symptoms can occur (REF). SS can derivative a psychopathological phenomenon called Seasonal Affective Disorder (SAD), that generate consequences in the social adaptation and perception of happiness of the individual, directly related to a lower quality of life (1,2,9,10). SAD severity includes a subsyndromal-SAD (S-SAD) cyclical form “winter blues” to a severe depression (11).

Physical activity is a non-pharmacological intervention that results in systemic changes, modulating the neuroendocrine system (REF), which attenuates depressive and anxiety symptoms and is an effective and accessible treatment for SAD and S-SAD (12). The benefits of incorporating regular exercise and maintaining a high level of physical activity as part of daily living activities have been extensively studied and are well known. Some of these are summarized as improved cardiorespiratory fitness, reduced risk of cardiometabolic diseases, improved self-esteem and mood, promotion of social integration, improved management of chronic diseases and many other associated benefits that translate into a better quality of life at different stages of life (13,14). On the other hand, it has been well studied those sedentary behaviors increase the risk of cardiovascular diseases, diabetes, obesity, stroke, among others (15,16). According to WHO, the classification of a physically active person considers that a certain amount of time of medium to high intensity physical exercise is met, for example, 150-300 minutes of medium to high intensity aerobic physical activity (17).

Physical activity can be performed both outdoors and indoors. Emerging evidence suggests that outdoor exercise promotes a decrease in perceived stress, mediated by the action of the parasympathetic nervous system; also, it may generate increases in vitamin D levels and a decrease in the risk of myopia compared to the same activity performed indoors (18–20). However, outdoor exercise may be hindered by fluctuating climatic conditions across the world. In high southern latitude areas, cold weather prevails for most of the year, and, at the same time, there are cyclical changes of natural light in relation to the seasons of the year, thus conditioning the life of the inhabitants of the region (21).

In Chile, 81.3% of the population engages in physical activity or sport (22). The Region of Magallanes and Chilean Antarctica is located in the extreme south of the country, which is classified as high southern latitude and is therefore characterized by a cold climate and seasonal changes in natural light. In this area, only 36.2% engage in physical activity or sport, which may or may not be directly influenced by geographical conditions and the seasonal cycle of light (23). Despite being practiced by less than half of the Chilean population, physical activity can be an intervention with a specific relevance for this population, if it results in an attenuation of the symptoms of SS. Even though this has been studied in other continents (24), the relationship between physical activity, SS and the well-being of people living in high southern latitude has not been studied in Latin America.

The main objective of this study is to evaluated the relationships between the practice of physical activity, SS and well-being in people living in a high southern latitude. We hypothesized that the practice of physical activity presents an inverse correlation with seasonal sensitivity and a positive correlation with well-being in southern latitude residents; also, the intensity of physical activity may influence these relationship.

# Material and methods

## Ethics

Participating subjects gave their permission through informed consent before participation. The Ethics Committee approved this study of the University of Magallanes, Chile (code: Nº045SH2019), following the regulations established by the Declaration of Helsinki on ethical principles in human beings. The volunteers were informed about the research objectives and all the experimental procedures before giving their written informed consent for participation in this study.

## Study design

This study is a non-experimental correlational study. It was conducted in a single stage by applying a presential questionnaire.

## Participants

The participants in this study were selected by non-random, accidental sampling from the city of Punta Arenas, Chile, located at latitude 53º south. High latitude south is defined as latitude 50º to the South Pole and considered as a geographical zone of extreme climate [25]. In total, 358 people participated in this study. Participants’ gender, age, city of origin, length of stay in the region and presence of psychological illnesses were registered using an anamnesis. The participants were invited to participate mainly through social networks and promotional posters of the research. Length of stay in the high latitude south ALS region was surveyed for each participant.

Inclusion criteria included being of legal age, residing in the city of Punta Arenas for at least six months of the year, not having any degree of disability, being able to read and answer the questionnaire. The exclusion criteria were: did not comply with the rules for filling out the form, were pregnant, and had incomplete answers to any of the questionnaires.

Three hundred and fifty-eight subjects were part of the final sample, with 56 % of males (n = 202) and 44% of females (n = 156). The age was grouped into subjects aged 18 to 35 years (n = 200) or older than 35 years (n = 158).

## Measures

### Seasonal pattern assessment questionnaire (SPAQ)

The Seasonal Profile Assessment Questionnaire (SPAQ) is a self-administered and timeless screening tool to access seasonal variation [26,27] experienced in six items: sleep duration, social activity, mood, weight, appetite, and energy level. Each item is rated on a five-point scale from “not changing” (0 points) to “changing a lot” (4 points). The sum of six SPAQ items produces an overall Seasonal Score Index (SSI, from 0 to 24 points), with higher scores corresponding to greater sensitivity to seasonal changes; Seasonal Affective Disorder (SAD), reflects a depressive picture with a seasonal pattern (SP); Winter Blues, which is a milder form of SAD, a sub-syndrome (S-SAD) [[28](#ref-melrose2015seasonal)]. Also, respondents indicated the degree of severity of seasonal changes from “light” (1 points) to “disabling” (5 points), determining whether seasonal changes are considered a problem.

The analysis of combination of SSI scores with the evaluation degree of severity of seasonal changes indicated the presence of SAD [(SSI ≥ 11 and seasonal changes are a problem reported as equal to or greater than moderate (≥2)] [1,29], or S-SAD, (GSS = 9 or 10 and the seasonal changes scored as equal problem or higher than moderate (≥2)) [28].

### Psychological well-being - Ryff scale

Psychological well-being (PWB) 42-item Ryff scale addresses six different dimensions: Self-acceptance, a person’s ability to feel good about themselves; Positive relationships, a person’s perception of establishing stable social relationships and having friends they can trust; Autonomy, a person’s ability to resist social pressure to a greater extent and to self-regulate their behavior; Environmental mastery, personal ability to choose or create favorable environments to meet one’s needs; Personal growth, striving to develop one’s potential and maximize one’s capabilities; Purpose in life, which refers to a person’s ability to define a set of goals that enable them to give their life some meaning. Each of these instruments is easy to apply, and in total, there are four sheets that were answered in a Likert-type format for the convenience and speed of the participant [30].

### Physical activity

The report on physical activity engagement was obtained using a survey of selection questions, and the classification of sports subjects was based on the WHO recommendations [17]. According to the WHO, a person is considered physically active when they engage in moderate-intensity aerobic physical activity for at least 150-300 minutes; intense aerobic physical activity for 75-150 minutes; or an equivalent combination of both moderate and intense activities throughout the week. Muscle-strengthening activities performed on two or more days in a week that involve all major muscle groups are also considered [17].

## Procedures

Participants voluntarily signed an informed consent form and then completed the detailed instruments in a single session in the following order: physical activity, SPAQ, psychological Ryff well-being scale and demographic data. These were self-administered during the winter, as the assessment of symptom presence is more direct at this time (average daylight hours winter: 2.8; summer: 7.4). Each examination was scheduled in a free time of 1-hour min to answer all questions.

## Statistical analysis

The data is presented as median (*Mdn*) and interquartile range (*IQR*) for continuous variables; for categorical/discrete variables, the absolute and relative sample size was reported.

A non-parametric approach was used since the underlying distribution of measured outcomes, assessed through analytical and graphical methods, did not follow a Gaussian distribution. The *Wilcoxon* () and *Kruskal-Wallis* () rank-sum tests were used for between-subjects analyses, meanwhile the chi-square test () was used to evaluate goodness-of-fit () and independence of factors (). In order to assess the association between numeric variables, *Spearman’s* rho statistic () was calculated. Effect sizes and their respective 95% confidence intervals are also presented for each statistic.

A probability of committing a type I () error of less than 5% (*p* < 0.05) was considered sufficient evidence for statistical significance in hypothesis testing. All the statistical analyses were computed and implemented in the R programming language [31].

# Results

Of the 358 volunteers, 216 (60.3%%) were classified as SAD and 55 (15.4%) as S-SAD. 194 persons (54.2%) reported be engaged in physical acttivity (for details, see Supplemental Material xx). Increasing levels of self-reporting of phisical activity intensity, there was a significant decrease in the proportion of people with SAD (Figure 1).

The SSI had a proportional effect on the summer pattern variable. Subjects classified within the SAD group scored higher on summer pattern than the Winter blues and Normal groups ( (2)= 20.76, *p* < 0.001, = 0.06, CI95%[0.03, 1.00]). A similar trend was observed for SSI on the winter pattern, where the SAD group recorded higher scores on the winter pattern than those in the Winter blues and Normal group ( (2) = 52.28, *p* < 0.001, = 0.15, CI95%[0.09, 1.00]); those with a mixed-type pattern had a higher proportion of people with SAD compared to those with a winter pattern (Figure 2b). Regarding self-reported severity of seasonal sensitivity, it was observed to have a positive effect on SSI (Figure 2a). Furthermore, a positive correlation between winter and summer patterns was observed ( = 0.48, CI95%[0.40, 0.56], *p* < 0.001). On the other hand, when looking at the relationship between seasonal sensitivity and participants’ well-being, a negative correlation was found between winter pattern and the subcategory of autonomy ( = -0.11, CI95%[-0.21, 0.00], *p* = 0.044).

In terms of gender, male subjects have a higher score in environmental control than females ( = 18106.5, *p* = 0.01, = 0.15, CI95%[0.04, 0.27]) and in turn a higher score on the purpose in life domain ( = 18084.5, *p* = 0.01, = 0.15, CI95%[0.03, 0.27]). A negative effect was found between SSI and five subcategories of the Ryff Well-Being Scale, namely self-acceptance, autonomy, environmental mastery, personal growth and purpose in life (Figure 3).

# Discussion

The main objective of this study was to determine the relationship between the practice of physical activity, SS and the well-being of people living in high southern latitudes. According to our results, 54.9% of our study population declares to perform some type of physical activity or sport, a figure higher than the records of 2017 in the Magallanes and Chilean Antarctica Region (23); this may be due to the fact that in these 5 years the population that performs physical activity has increased.

In our study population, 76% have some degree of SS and of this percentage, 87% consider that seasonality is a problem for them. In university students, who circumstantially live in high latitudes, it has been seen that almost half of the subjects studied do not perceive SS as a problem (2). This difference could be due to the fact that circumstantial exposure to seasonal changes does not allow it to be perceived as a problem, unlike those who live permanently under these environmental conditions. In addition, at present, residents of high latitudes are more informed that the characteristics of the geographical area where they live can influence their health, as well as their mood and mental health. Based on the above, a direct relationship was found between SS and the perceived severity classification of SS (Figure 2), where the greater the perceived severity, the greater the proportion of people with SS. However, there is still a percentage of people who still believe that SS is not a problem for them and therefore do not take action despite the fact that seasonal light affects them.

On the other hand, 84% declare to exercise with a medium to high intensity of physical activity. The variable reported by the study subjects is inversely related to SS. Thus, it can be considered that the more intense the physical activity, the lower the probability of SS (Figure 2). This may be due to the fact that physical activity can generate a regulation of the circadian rhythm generating a lower perception of SS. In the review by Escames et al. (32) it is mentioned that exercise of varying duration and intensity can generate changes in the circadian cycle independent of the time of exposure to light. On the other hand, one of the best-known benefits of exercise is the improvement of mood disorders which may be another reason why there is an association between the intensity of the activity and the perception of SS (33–35).

Regarding the perception of psychological well-being, an inverse relationship was found between SS and multiple domains of the Ryff Scale: self-acceptance, autonomy, control of the environment, personal growth and life goals. The presence of SS has a negative impact on the psychological well-being of the subject, which can lead to a decrease in the performance of physical activity and sports, further increasing the probability of suffering from some degree of SS.

This cyclical relationship between psychological well-being, seasonal sensitivity and exercise is a determining factor to take into account considering that the study area is one of the southernmost areas of the world with a high rate of tourism and, therefore, with high flow of people (36), since seasonal light changes can generate variations in their previous psychological well-being. It is important to raise awareness of the benefits of physical activity in these areas to avoid or reduce the impact of SS on psychological well-being.

One of the limitations of this study is that it was not possible to control the type of physical activity performed by the participants, which could generate a degree of error in the categorization of the type of exercise performed.

Future research should include physiological measurements to determine the impact of SS on biological domains.

# Conclusion

# In this study, it was possible to determine that people who engage in higher intensity physical activity may have less SS. On the other hand, SS can affect psychological well-being in multiple domains. Nevertheless, many people with SS do not perceive it as a problem.

Based on findings of the present study sports programmes can be designed considering the reality of these regions and thus promote physical activity and sport, favouring the health of the inhabitants with absolute relevance in their development.

# Data availability statement

The original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding author/s.

# Ethics Statement

The studies involving human participants were reviewed and approved by The Ethics Committee of the University of Magallanes, Chile (Nº141CEC2018). The patients/participants provided their written informed consent to participate in this study.

# Author Contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

# Conflicts of interest

The authors declare that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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##### **Figure captions**

**Figure 1**. Cumulative bar plots indicating the observed proportions between the levels of SSI and the intensity of physical activity.

**Figure 2**. Cumulative bar plots indicating observed proportions between different levels of SSI and (A) the severity of self-perceived seasonality, (B) and the proportions between the type of seasonal pattern.

**Figure 3**. Violin plots indicating the observed differences between different SSI levels on Ryff’s parameters of psychological well-being. For each panel, Dunn’s test was applied and highlighted for every significative pairwise difference. P-values are shown unadjusted for multiple comparisons (given the exploratory nature of the study).