

**ROSOŁOWSKA-ŻAK, Sara, SAMBURA, Sambura, PASCHKE, Patrycja, MICZEK, Igor, PALUCHOWSKA, Julia and SZYMKOWICZ, Anna. The influence of sport climbing on depressive disorders. Quality in Sport. 2024;16:50572. eISSN 2450-3118. DOI <https://dx.doi.org/10.12775/QS.2024.16.003> <https://apcz.umk.pl/QS/article/view/50572>**

The journal has had 20 points in Ministry of Higher Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Higher Education and Science of 05.01.2024. No. 32553. Has a Journal's Unique Identifier: 201398. Scientific disciplines assigned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences). Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 r. Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przepisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych). © The Authors 2024. This article is published with open access at Licensee Open Journal Systems of Nicolaus Copernicus University in Torun, Poland Open Access. This article is distributed under the terms of the Creative Commons Attribution Noncommercial License which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author (s) and source are credited. This is an open access article licensed under the terms of the Creative Commons Attribution Non commercial license Share alike. (<http://creativecommons.org/licenses/by-nc-sa/4.0>) which permits unrestricted, non commercial use, distribution and reproduction in any medium, provided the work is properly cited. The authors declare that there is no conflict of interests regarding the publication of this paper. Received: 27.03.2024. Revised: 25.04.2024. Accepted: 25.04.2024. Published: 27.04.2024.

## **The influence of sport climbing on depressive disorders**

Sara Rosołowska-Żak;

ORCID 0009-0003-6202-2475

<https://orcid.org/0009-0003-6202-2475>; [sararosołowska@gmail.com](mailto:sararosołowska@gmail.com);

Wojewódzki Szpital Specjalistyczny nr 5 im. św. Barbary w Sosnowcu, Plac Medyków 1,

41-200 Sosnowiec, Poland.

Maria Sambura;

ORCID 0009-0007-5518-1418;

<https://orcid.org/0009-0007-5518-1418>; [maria.e.sambura@gmail.com](mailto:maria.e.sambura@gmail.com);

Wojewódzki Szpital Specjalistyczny nr 5 im. św. Barbary w Sosnowcu, Plac Medyków 1,

41-200 Sosnowiec, Poland.

Patrycja Paschke;

ORCID 0009-0006-0306-3332;

<https://orcid.org/0009-0006-0306-3332>; [paschke.patrycja@gmail.com](mailto:paschke.patrycja@gmail.com);

SP ZOZ MSWiA w Katowicach im. Sierżanta Grzegorza Załogi

Ul. Wita Stwosza 41, 40-514 Katowice. Poland.

Igor Miczek

ORCID 0009-0000-8476-7943;

<https://orcid.org/0009-0000-8476-7943>; [miczekigor222@gmail.com](mailto:miczekigor222@gmail.com);

SP ZOZ MSWiA w Katowicach im. Sierżanta Grzegorza Załogi

Ul. Wita Stwosza 41, 40-514 Katowice. Poland.

Julia Pałuchowska;

ORCID 0009-0009-4163-2569;

<https://orcid.org/0009-0009-4163-2569>; [Julia.paluchowska@o2.pl](mailto:Julia.paluchowska@o2.pl)

ZOZ w Nysie ul. Bohaterów Warszawy 23 48-300 Nysa. Poland.

Anna Szymkowicz;

ORCID 0009-0009-2596-6593;

<https://orcid.org/0009-0009-2596-6593>; [a.szymkowicz98@gmail.com](mailto:a.szymkowicz98@gmail.com);

ZOZ w Nysie, ul. Bohaterów Warszawy 23, 48-300 Nysa. Poland.

Corresponding author:

Sara Rosołowska-Żak;

full postal address: Ułańska street 7/128, 40-887 Katowice, Poland;

telephone: +48 694 302 151;

e-mail: [sararosolowska@gmail.com](mailto:sararosolowska@gmail.com)

## **Abstract**

### **Introduction:**

According to the World Health Organization (WHO), depression is the most common mental disorder, affecting a significant percentage of the adult population. The disease is associated with many negative health consequences and is one of the leading causes of disability and inability to work worldwide. Sports climbing can be a great method, complementary to psychotherapy, used to reduce the symptoms of depressive disorders.

**Aim of the study:**

The aim of our work is to review and summarize the most interesting conclusions from research on the impact of climbing as a complementary form of treatment for depressive disorders.

**Material and methods:**

We conducted a review of scientific publications published in the years 2004-2024 in English and Polish in the PubMed and Google Scholar databases. We used keywords such as "depression" and "sport climbing".

**Conclusions:**

Research shows that sport climbing can alleviate depressive symptoms, have a positive impact on emotion regulation and lead to changes in brain functioning.

**Key words:**

Depression, mental disorders, physical activity, climbing, bouldering, emotion regulation.

**Introduction**

Depression is one of the most common pathological conditions encountered in the population. It ranks among the 12 major causes of Disability-Adjusted Life Years (DALY) worldwide [1], leading to significant health, social, and economic consequences [2] . According to the World Health Organization, 3.8% of the population experiences depression, including 5% of adults (4% among men and 6% among women) and 5.7% of adults over 60 years old. Suicide, the fourth leading cause of death in individuals aged 15–29, is the most serious complication of depressive disorders[3]. Statistics indicate that women are twice as likely to suffer from depression and anxiety disorders [4], while men are more prone to

substance abuse and addiction [5]. Typical symptoms of depression listed in the ICD-10 diagnostic criteria include:

- lowered mood,
- decreased or loss of previous interests,
- changes in appetite and body weight,
- insomnia or excessive sleepiness,
- chronic fatigue,
- cognitive disturbances.

Additionally, suicidal thoughts and attempts may occur in patients with depression [6]. Besides the significant burden on mental health, there is increasing evidence suggesting that depression also contributes to the deterioration of somatic health [7]. It can lead to an increased incidence of cardiovascular diseases [8], diabetes [9] and neurodegenerative diseases associated with dementia [10]. Identifying the precise brain region responsible for the onset of depression symptoms is not easy. Based on the existing research, scientists point to the potential significance of dysfunction in areas such as the left dorsolateral and medial prefrontal cortex, as well as limbic system structures, primarily the amygdala [11]. There are also pathophysiological indications suggesting the essential role of the cerebellum in the development of depression [12].

Rock climbing, sport climbing, and bouldering are sports activities that have been gaining increasing popularity in recent years. The growing number of climbing gyms nationwide provides the opportunity for regular engagement in this sport regardless of the weather [13]. In sport climbing, climbers move along designated routes up to approximately 30 meters, with fixed safety points placed at sporadic intervals. To protect against the potential consequences of falling, climbers place a rope to the hanging quickdraws [14]. Another variant of sport climbing is bouldering, where route heights are limited to a few meters, and instead of a rope, special mats are used for protection, allowing climbers to safely jump [15]. Sport climbers use dedicated shoes and magnesium carbonate (magnesia) to dry and reduce hand perspiration. Completing a climbing route is recognized by successfully overcoming it without falling or intentionally hanging on the safety points, along with statically holding the last grip with both hands [16].

## **Climbing and Alleviating Depression Symptoms**

In recent years, there has been an emphasis on the significant impact of regular physical activity on mental well-being and proper cognitive function [17]. Physical activity stimulates the sympathetic nervous system and reactivity of the hypothalamus-pituitary-adrenal axis, improving the health status in depressive disorders. Furthermore, it enhances neurogenesis and has a positive influence on brain neurotransmitters such as serotonin, dopamine, endorphins, and norepinephrine [18]. Physical exercise is said to positively affect depression by increasing the release of  $\beta$ -endorphins, which are responsible for a positive mood and improved well-being [19].

Several prospective studies have been published to investigate the impact of climbing as a supportive method in the therapeutic process for patients with depressive disorders. One example is the study by Schwarz and colleagues. In this study, the presence and severity of symptoms were assessed using the Beck Depression Inventory – Second Edition (BDI-II) [20]. The BDI is designed for individuals aged 13 and older, consisting of 21 questions. Each item corresponds to a specific depression symptom, and respondents select statements that best reflect their state over the past two weeks. Responses are scored from 0 to 3 points, based on symptom intensity. The overall score determines the degree of depression as none, moderate, or severe [21]. Results from the study by Schwarz et al. indicate a positive short- and long-term impact of bouldering on the severity of depression. Over the 8-week period, during which participants engaged in climbing once a week for 3 hours, the severity of depressive symptoms, as assessed on the Beck scale, decreased by 7.21 points. The level of depression moved from moderate to mild, and this effect persisted over the 12-month observation period [20].

In the study by Luttenberger and colleagues, two objectives were outlined: the development of an eight-week program that combines psychotherapeutic interventions with bouldering and the assessment of the role of this physical activity in individuals with depression [22]. The study included 22 participants in the experimental group and 25 in the control group. Similar to the study by Schwarz et al., the intervention took place once a week, lasting three hours, over an eight-week period. Participants completed the Beck Depression Inventory II (BDI-II), the Symptom Checklist-90 (SCL-90) questionnaire, the questionnaire on resources and self-management skills (FERUS), and the d2-R attention test. It was determined that depressive symptoms were reduced by an average of 6 points on the BDI-II

scale [22]. Furthermore, the effect of this intervention on the severity of depression was evaluated, showing comparable outcomes to other short-term group therapies [23].

Another study that examined the impact of bouldering on the treatment process of depression was conducted by Stelzer and colleagues. They assessed its effectiveness in reducing depressive symptoms considering general physical activity [24]. The study involved 27 participants, while the control group consisted of 29 individuals. The intervention lasted for 8 weeks, with participants meeting once a week for a three-hour training session. All sessions were supervised by at least two mental health therapists experienced in bouldering and rock climbing. Each of the eight sessions focused on a specific psychological process that, according to the researchers, could play a role in reducing depressive symptoms. Evaluation of all participants was conducted at the beginning of the study and after 8, 16, and 24 weeks. The Beck Depression Inventory II (BDI-II), The Symptom Checklist-90-R (SCL-90-R), and the questionnaire on resources and self-management skills (FERUS) were used to analyze the presence and severity of depressive symptoms. Physical activity intensity was assessed using the FitBit Zip device. The authors observed a decrease in the severity of depression, measured by the SCL-90-R questionnaire, by 6.74 points and by 8.26 points in the BDI-II compared to the results collected before the start of training. All participants averaged 6515 steps per day, considered as "low activity." The conclusions state that the conducted research confirms that bouldering therapy can be effective in treating depression. Even considering other variables such as psychotherapy, the use of antidepressant medications, and the overall level of physical activity, bouldering still proves to be a significant independent factor in reducing depressive symptoms [24].

In climbing, maintaining a high level of concentration and coordination is necessary. These are factors that can successfully counteract cognitive deficits in patients with depression [25]. Focusing on the activity provides an opportunity to temporarily divert attention from negative thoughts and worries, giving a sense of relief [22]. Due to the often-present obsessive thoughts, known as rumination, in depressive disorders, strengthening mindfulness can be helpful in the therapeutic process [26].

### **Emotion regulation**

Emotion regulation can be defined as the processes through which individuals influence the emotions they have, when and how they experience them, and how they express it [27]. It

has been proven that deficits in emotion regulation are a significant mechanism in depression [28]. Kleinstäuber and colleagues assessed the relationship between rock climbing and emotion regulation in patients with severe depression. To assess the level of depression, criteria from The Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) and the Patient Health Questionnaire-9 (PHQ-9) were used. Participants engaged in rock climbing for 7 months, once a week for 2.5 hours. It was observed that after completing the training, the numerical results of questionnaires assessing the severity of disorders were significantly lower. The authors concluded that climbing positively influences the ability to regulate emotions, which is crucial in maintaining the effects of depression treatment [29].

One of the most frequently mentioned neurotransmitter systems whose dysregulation is observed in depression is the dopaminergic system [30]. Researchers seek a connection between reduced dopaminergic transmission and increased processing of negative emotional stimuli [31]. Numerous studies have confirmed the impact of learning on dopamine release [32]. When climbing, individuals experience continuous learning of movements, sequences, body positioning, or gripping techniques [33]. As a result, there is a post-training significant increase in dopamine levels [34].

Another advantage of rock climbing is that it can evoke intense positive emotions, such as pride [35]. It is a sport that requires a significant time investment, as well as long-term planning and organization [36]. These factors give participants a sense of fulfillment, satisfaction, and the belief in their ability to achieve goals. Individuals may realize that they are capable of overcoming challenges independent of them (e.g., a difficult, demanding route) and conquering their fears (e.g., fear of heights) [36]. Such experiences contribute to building self-esteem, which is often significantly reduced in depressive disorders [35].

### **The role of the cerebellum in depression**

It has been proven that emotionally charged events are easier to remember than neutral events due to their encoding and vivid memories [37]. This phenomenon is known as emotional memory enhancement [38]. Abnormalities in emotional memory have been observed in patients with severe depressive disorders [39]. Individuals with depressive disorders tend to remember or process information that aligns with their mood state.

Therefore, patients with depressive symptoms show an increased tendency to recall negatively charged memories and a decreased tendency to recall positive ones [40]. Xu et al.'s study demonstrates that among individuals with severe depression, emotional memory and the severity of depressive symptoms are associated with structural changes in both the posterior and anterior regions of the gray matter in the cerebellum [41]. The recorded abnormalities within this structure include abnormal activity [42], reduced regional homogeneity [43], increased functional connectivity between the cerebellum and temporal poles [44] and reduced cerebellar volume [45]. Considering these observations, one can hypothetically explain the impact of cerebellar stimulation on the effectiveness of therapy in individuals with depression. Animal studies have compared the vermis of adult rats subjected to challenging acrobatic training with rats subjected to intense physical exercises or those that were inactive. An increase in the size and number of synapses of Purkinje cells was observed in animals undergoing acrobatic training compared to the other two groups of rats. This suggests that learning new motor skills, as opposed to practicing other physical activities, generates new synapses in the cerebellar cortex [46]. On the other hand, impairment of Purkinje cell function leads to abnormal social and motor behaviors [47].

### **Social Functions of Climbing**

Rock climbing requires collaboration between individuals, social interaction, and trust in one's climbing partner. This cooperative aspect contributes to building relationships and bonds with other people [29]. Additionally, in bouldering therapy, participants are trained in mutual support, securing each other, working together to find possible routes, and providing feedback and appreciation for fellow participants. Social interaction can thus serve as a powerful therapeutic element in bouldering therapy [22].

### **Contact with nature**

It is worth noting that rock climbing takes place in a natural environment, outdoors, often in picturesque settings. The contact with nature elicits a decidedly positive emotional response. Moreover, time spent in nature, or even just viewing nature-related scenes, improves concentration and cognitive functioning [48]. Numerous meta-analyses have shown that individuals who regularly experience contact with nature feel more happiness, energy,



and life satisfaction [49]. The positive impact on relationships with others, personal development, and vitality is also emphasized [50].

### **Summary**

Further studies focusing on assessing the impact of rock climbing on the therapeutic process of individuals suffering from depression are necessary. The proposed physical activity appears promising as a complementary form of treatment to pharmacological and psychotherapeutic approaches to treating depression.

### **Author's contribution**

Conceptualization: Sara Rosołowska-Żak, Maria Sambura

Methodology: Sara Rosołowska-Żak, Igor Miczek

Software: Anna Szymkowicz, Patrycja Paschke

Check: Igor Miczek, Patrycja Paschke

Formal analysis: Sara Rosołowska-Żak, Julia Pałuchowska

Investigation: Anna Szymkowicz, Patrycja Paschke

Resources: Patrycja Paschke, Maria Sambura

Data curation: Anna Szymkowicz, Igor Miczek

Writing - rough preparation: Sara Rosołowska-Żak, Igor Miczek

Writing - review and editing: Maria Sambura, Julia Pałuchowska

Visualization: Anna Szymkowicz, Igor Miczek

Supervision: Julia Pałuchowska, Patrycja Paschke

Project administration: Maria Sambura

Receiving funding: no funding was received.

All authors have read and agreed with the published version of the manuscript.

Disclosures: No disclosures.

Financial support: No financial support was received.

Conflict of interest: The authors declare no conflict of interest.

## References:

- [1] C. J. L. Murray *et al.*, “Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010,” *The Lancet*, vol. 380, no. 9859, pp. 2197–2223, Dec. 2012, doi: 10.1016/S0140-6736(12)61689-4.
- [2] D. Chisholm *et al.*, “Scaling-up treatment of depression and anxiety: a global return on investment analysis,” *Lancet Psychiatry*, vol. 3, no. 5, pp. 415–424, May 2016, doi: 10.1016/S2215-0366(16)30024-4.
- [3] “Depressive disorder (depression).” Accessed: Dec. 21, 2023. [Online]. Available: <https://www.who.int/news-room/fact-sheets/detail/depression>
- [4] R. C. Kessler and E. J. Bromet, “The epidemiology of depression across cultures,” *Annu. Rev. Public Health*, vol. 34, pp. 119–138, 2013, doi: 10.1146/annurev-publhealth-031912-114409.
- [5] S. Seedat *et al.*, “Cross-national associations between gender and mental disorders in the World Health Organization World Mental Health Surveys,” *Arch. Gen. Psychiatry*, vol. 66, no. 7, pp. 785–795, Jul. 2009, doi: 10.1001/archgenpsychiatry.2009.36.
- [6] F. B. Schuch and B. Stubbs, “The Role of Exercise in Preventing and Treating Depression,” *Curr. Sports Med. Rep.*, vol. 18, no. 8, p. 299, Aug. 2019, doi: 10.1249/JSR.0000000000000620.
- [7] S. Moussavi, S. Chatterji, E. Verdes, A. Tandon, V. Patel, and B. Ustun, “Depression, chronic diseases, and decrements in health: results from the World Health Surveys,” *The*

- Lancet*, vol. 370, no. 9590, pp. 851–858, Sep. 2007, doi: 10.1016/S0140-6736(07)61415-9.
- [8] C. U. Correll *et al.*, “Prevalence, incidence and mortality from cardiovascular disease in patients with pooled and specific severe mental illness: a large-scale meta-analysis of 3,211,768 patients and 113,383,368 controls,” *World Psychiatry*, vol. 16, no. 2, pp. 163–180, 2017, doi: 10.1002/wps.20420.
- [9] D. Vancampfort *et al.*, “Diabetes mellitus in people with schizophrenia, bipolar disorder and major depressive disorder: a systematic review and large scale meta-analysis,” *World Psychiatry*, vol. 15, no. 2, pp. 166–174, 2016, doi: 10.1002/wps.20309.
- [10] G. Z. Réus *et al.*, “Neurochemical correlation between major depressive disorder and neurodegenerative diseases,” *Life Sci.*, vol. 158, pp. 121–129, Aug. 2016, doi: 10.1016/j.lfs.2016.06.027.
- [11] M. Pandya, M. Altinay, D. A. Malone, and A. Anand, “Where in the brain is depression?,” *Curr. Psychiatry Rep.*, vol. 14, no. 6, pp. 634–642, Dec. 2012, doi: 10.1007/s11920-012-0322-7.
- [12] M. S. Depping, M. M. Schmitgen, K. M. Kubera, and R. C. Wolf, “Cerebellar Contributions to Major Depression,” *Front. Psychiatry*, vol. 9, p. 634, Nov. 2018, doi: 10.3389/fpsy.2018.00634.
- [13] A. Schweizer, “Sport climbing from a medical point of view,” *Swiss Med. Wkly.*, vol. 142, p. w13688, 2012, doi: 10.4414/smw.2012.13688.
- [14] K. Y. Woollings, C. D. McKay, and C. A. Emery, “Risk factors for injury in sport climbing and bouldering: a systematic review of the literature,” *Br. J. Sports Med.*, vol. 49, no. 17, pp. 1094–1099, Sep. 2015, doi: 10.1136/bjsports-2014-094372.
- [15] L. Dorscht, N. Karg, S. Book, E. Graessel, J. Kornhuber, and K. Luttenberger, “A German climbing study on depression: a bouldering psychotherapeutic group intervention in outpatients compared with state-of-the-art cognitive behavioural group therapy and physical activation – study protocol for a multicentre randomised controlled trial,” *BMC Psychiatry*, vol. 19, no. 1, p. 154, May 2019, doi: 10.1186/s12888-019-2140-5.
- [16] G. Zieliński, E. Zięba, and A. Byś, “Review of studies on the impact of climbing as a complementary form of depression treatment and their evaluation according to the QUADAS-2 tool,” *Psychiatr. Pol.*, vol. 55, no. 6, pp. 1341–1356, Dec. 2021, doi: 10.12740/PP/126445.

- [17] B. Gieroba, "The impact of physical activity on mental health and cognitive functions," *Med. General Health Sciences*, vol. 25, no. 3, pp. 153–161, Sep. 2019, doi: 10.26444/monz/112259.
- [18] E. Anderson and G. Shivakumar, "Effects of Exercise and Physical Activity on Anxiety," *Front. Psychiatry*, vol. 4, 2013, Accessed: Dec. 22, 2023. [Online]. Available: <https://www.frontiersin.org/articles/10.3389/fpsyt.2013.00027>
- [19] L. L. Craft and F. M. Perna, "The Benefits of Exercise for the Clinically Depressed," *Prim. Care Companion J. Clin. Psychiatry*, vol. 6, no. 3, pp. 104–111, 2004.
- [20] L. Schwarz, L. Dorscht, S. Book, E.-M. Stelzer, J. Kornhuber, and K. Luttenberger, "Long-term effects of bouldering psychotherapy on depression: benefits can be maintained across a 12-month follow-up," *Heliyon*, vol. 5, no. 12, p. e02929, Dec. 2019, doi: 10.1016/j.heliyon.2019.e02929.
- [21] G. Jackson-Koku, "Beck Depression Inventory," *Occup. Med.*, vol. 66, no. 2, pp. 174–175, Mar. 2016, doi: 10.1093/occmed/kqv087.
- [22] K. Luttenberger, E.-M. Stelzer, S. Först, M. Schopper, J. Kornhuber, and S. Book, "Indoor rock climbing (bouldering) as a new treatment for depression: study design of a waitlist-controlled randomized group pilot study and the first results," *BMC Psychiatry*, vol. 15, no. 1, p. 201, Aug. 2015, doi: 10.1186/s12888-015-0585-8.
- [23] W. McDermut, I. W. Miller, and R. A. Brown, "The Efficacy of Group Psychotherapy for Depression: A Meta-analysis and Review of the Empirical Research," *Clin. Psychol. Sci. Pract.*, vol. 8, no. 1, pp. 98–116, 2001, doi: 10.1093/clipsy.8.1.98.
- [24] E.-M. Stelzer, S. Book, E. Graessel, B. Hofner, J. Kornhuber, and K. Luttenberger, "Bouldering psychotherapy reduces depressive symptoms even when general physical activity is controlled for: A randomized controlled trial," *Heliyon*, vol. 4, no. 3, p. e00580, Mar. 2018, doi: 10.1016/j.heliyon.2018.e00580.
- [25] A. Sanchez, C. Vazquez, C. Marker, J. LeMoult, and J. Joormann, "Attentional disengagement predicts stress recovery in depression: An eye-tracking study," *J. Abnorm. Psychol.*, vol. 122, no. 2, pp. 303–313, 2013, doi: 10.1037/a0031529.
- [26] M. A. Kenny and J. M. G. Williams, "Treatment-resistant depressed patients show a good response to Mindfulness-based Cognitive Therapy," *Behav. Res. Ther.*, vol. 45, no. 3, pp. 617–625, Mar. 2007, doi: 10.1016/j.brat.2006.04.008.
- [27] "The Emerging Field of Emotion Regulation: An Integrative Review - James J. Gross, 1998." Accessed: Jan. 02, 2024. [Online]. Available: <https://journals.sagepub.com/doi/full/10.1037/1089-2680.2.3.271>

- [28] J. Joormann and M. E. Quinn, “Cognitive Processes and Emotion Regulation in Depression,” *Depress. Anxiety*, vol. 31, no. 4, pp. 308–315, 2014, doi: 10.1002/da.22264.
- [29] M. Kleinstäuber, M. Reuter, N. Doll, and A. J. Fallgatter, “Rock climbing and acute emotion regulation in patients with major depressive disorder in the context of a psychological inpatient treatment: a controlled pilot trial,” *Psychol. Res. Behav. Manag.*, vol. 10, pp. 277–281, Aug. 2017, doi: 10.2147/PRBM.S143830.
- [30] P. Belujon and A. A. Grace, “Dopamine System Dysregulation in Major Depressive Disorders,” *Int. J. Neuropsychopharmacol.*, vol. 20, no. 12, pp. 1036–1046, Jun. 2017, doi: 10.1093/ijnp/pyx056.
- [31] E. Cawley *et al.*, “Dopamine and light: effects on facial emotion recognition,” *J. Psychopharmacol. Oxf. Engl.*, vol. 31, no. 9, pp. 1225–1233, Sep. 2017, doi: 10.1177/0269881117711707.
- [32] A. M. Young, R. G. Ahier, R. L. Upton, M. H. Joseph, and J. A. Gray, “Increased extracellular dopamine in the nucleus accumbens of the rat during associative learning of neutral stimuli,” *Neuroscience*, vol. 83, no. 4, pp. 1175–1183, Apr. 1998, doi: 10.1016/s0306-4522(97)00483-1.
- [33] D. Hague and D. Hunter, *Rock Climbing*, Bellona, 2009.
- [34] M. Chalimoniuk and J. Langfort, Dopamine as a Mediator of the Extrapyramidal System Participating in the Regulation of Movement, "Kosmos", vol. 69, no. 4, Art. no. 4, 2020, doi: 10.36921/kos.2020\_2738.
- [35] J. H. Kerr and S. Houge Mackenzie, “Multiple motives for participating in adventure sports,” *Psychol. Sport Exerc.*, vol. 13, no. 5, pp. 649–657, Sep. 2012, doi: 10.1016/j.psychsport.2012.04.002.
- [36] T. Woodman, L. Hardy, M. Barlow, and C. L. Scanff, “Motives for participation in prolonged engagement high-risk sports: An agentic emotion regulation perspective,” *Psychol. Sport Exerc.*, vol. 11, no. 5, p. 345, 2010.
- [37] M. M. Bradley, M. K. Greenwald, M. C. Petry, and P. J. Lang, “Remembering pictures: pleasure and arousal in memory,” *J. Exp. Psychol. Learn. Mem. Cogn.*, vol. 18, no. 2, pp. 379–390, Mar. 1992, doi: 10.1037//0278-7393.18.2.379.
- [38] T. Sommer, J. Gläscher, S. Moritz, and C. Büchel, “Emotional enhancement effect of memory: removing the influence of cognitive factors,” *Learn. Mem. Cold Spring Harb. N.*, vol. 15, no. 8, pp. 569–573, Aug. 2008, doi: 10.1101/lm.995108.
- [39] E. Gilboa-Schechtman, D. Erhard-Weiss, and P. Jeczemien, “Interpersonal deficits meet cognitive biases: memory for facial expressions in depressed and anxious men and

- women,” *Psychiatry Res.*, vol. 113, no. 3, pp. 279–293, Dec. 2002, doi: 10.1016/s0165-1781(02)00266-4.
- [40] R. J. Holt *et al.*, “Functional MRI of emotional memory in adolescent depression,” *Dev. Cogn. Neurosci.*, vol. 19, pp. 31–41, Jun. 2016, doi: 10.1016/j.dcn.2015.12.013.
- [41] L. Xu *et al.*, “Relationship between cerebellar structure and emotional memory in depression,” *Brain Behav.*, vol. 7, no. 7, p. e00738, May 2017, doi: 10.1002/brb3.738.
- [42] S. L. Naismith, J. Lagopoulos, P. B. Ward, C. G. Davey, C. Little, and I. B. Hickie, “Fronto-striatal correlates of impaired implicit sequence learning in major depression: an fMRI study,” *J. Affect. Disord.*, vol. 125, no. 1–3, pp. 256–261, Sep. 2010, doi: 10.1016/j.jad.2010.02.114.
- [43] W. Guo *et al.*, “Disrupted regional homogeneity in treatment-resistant depression: a resting-state fMRI study,” *Prog. Neuropsychopharmacol. Biol. Psychiatry*, vol. 35, no. 5, pp. 1297–1302, Jul. 2011, doi: 10.1016/j.pnpbp.2011.02.006.
- [44] L. Liu *et al.*, “Altered cerebellar functional connectivity with intrinsic connectivity networks in adults with major depressive disorder,” *PloS One*, vol. 7, no. 6, p. e39516, 2012, doi: 10.1371/journal.pone.0039516.
- [45] L. Baldaçara, J. G. F. Borgio, A. L. T. de Lacerda, and A. P. Jackowski, “Cerebellum and psychiatric disorders,” *Rev. Bras. Psiquiatr. Sao Paulo Braz. 1999*, vol. 30, no. 3, pp. 281–289, Sep. 2008, doi: 10.1590/s1516-44462008000300016.
- [46] J. E. Black, K. R. Isaacs, B. J. Anderson, A. A. Alcantara, and W. T. Greenough, “Learning causes synaptogenesis, whereas motor activity causes angiogenesis, in cerebellar cortex of adult rats,” *Proc. Natl. Acad. Sci. U. S. A.*, vol. 87, no. 14, pp. 5568–5572, Jul. 1990, doi: 10.1073/pnas.87.14.5568.
- [47] P. T. Tsai *et al.*, “Autistic-like behaviour and cerebellar dysfunction in Purkinje cell Tsc1 mutant mice,” *Nature*, vol. 488, no. 7413, pp. 647–651, Aug. 2012, doi: 10.1038/nature11310.
- [48] W. Swędziół, “Natural Spaces as an Area for Health Promotion – Selected Cognitive Perspectives and a Review of Research,” *Soc. Work Rev.*, vol. 2018, no. Volume 23, number 4, Art. no. Volume 23, number 4 Dec. 2018, doi: 10.4467/24496138ZPS.18.020.10075.
- [49] C. A. Capaldi, R. L. Dopko, and J. M. Zelenski, “The relationship between nature connectedness and happiness: a meta-analysis,” *Front. Psychol.*, vol. 5, 2014, Accessed: Jan. 08, 2024. [Online]. Available: <https://www.frontiersin.org/articles/10.3389/fpsyg.2014.00976>

- [50] A. Pritchard, M. Richardson, D. Sheffield, and K. McEwan, “The Relationship Between Nature Connectedness and Eudaimonic Well-Being: A Meta-analysis,” *J. Happiness Stud.*, vol. 21, no. 3, pp. 1145–1167, Mar. 2020, doi: 10.1007/s10902-019-00118-6.