

**BASIURA, Karolina, STARZOMSKA, Dominika, RYMASZEWSKA, Katarzyna, PUCHAŁA, Justyna, GAJDZIŃSKA, Natalia, ROSTKOWSKA, Weronika, SALWA, Adam, RUTKOWSKI, Wojciech, RZEPKA, Maciej and SZTUBA, Karolina. The association between hypothyroidism, mental disorders and physical activity: a comprehensive review. Quality in Sport. 2024;16:52499. eISSN 2450-3118.**

<https://dx.doi.org/10.12775/QS.2024.16.52499>

<https://apcz.umk.pl/QS/article/view/52499>

The journal has been 20 points in the 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.

Przypisane 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: 12.06.2024. Revised: 30.06.2024. Accepted: 08.07.2024. Published: 12.07.2024.

## THE ASSOCIATION BETWEEN HYPOTHYROIDISM, MENTAL DISORDERS AND PHYSICAL ACTIVITY: A COMPREHENSIVE REVIEW

Karolina Basiura, Dominika Starzomska, Katarzyna Rymaszewska, Justyna Puchała, Natalia Gajdzińska, Weronika Rostkowska, Adam Salwa, Wojciech Rutkowski, Maciej Rzepka, Karolina Sztuba

Karolina Basiura

ORCID 00009-0002-2680-4114

<https://orcid.org/0009-0002-2680-4114>

2nd Speciality Hospital in Bytom, ul. Stefana Batorego 15, 41-902 Bytom, Poland

Dominika Starzomska

ORCID 0009-0006-1607-2502

<https://orcid.org/0009-0006-1607-2502>

Independent Public Health Care Institute of the Ministry of Internal Affairs and Administration in Katowice, ul. Wita Stwosza 41, 40-514 Katowice

Katarzyna Rymaszewska

ORCID 0009-0006-1848-1991

<https://orcid.org/0009-0006-1848-1991>

Independent Public Health Care Institute of the Ministry of Internal Affairs and Administration in Katowice, ul. Wita Stwosza 41, 40-514 Katowice

Justyna Puchała

ORCID 0009-0002-6155-6670

<https://orcid.org/0009-0002-6155-6670>

Independent Public Health Care Institute of the Ministry of Internal Affairs and Administration in Katowice,  
ul. Wita Stwosza 41, 40-514 Katowice

Natalia Gajdzińska

ORCID 0009-0009-1072-2895

<https://orcid.org/0009-0009-1072-2895>; [gajdzinska.natalia@gmail.com](mailto:gajdzinska.natalia@gmail.com)

Independent Public Health Care Institute of the Ministry of Internal Affairs and Administration in Katowice,  
ul. Wita Stwosza 41, 40-514 Katowice, Poland

Weronika Rostkowska

ORCID 0009-0009-3759-9989

<https://orcid.org/0009-0009-3759-9989>; [weronika.rostkowska97@gmail.com](mailto:weronika.rostkowska97@gmail.com)

Narutowicz City Speciality Hospital at Krakow, ul Prądnicza 35-37; 31-202 Kraków

Adam Salwa

ORCID 0009-0009-2534-7872

<https://orcid.org/0009-0009-2534-7872>; [asalwa97@gmail.com](mailto:asalwa97@gmail.com)

Independent Public Health Care Institute of the Ministry of Internal Affairs and Administration in Katowice,  
ul. Wita Stwosza 41, 40-514 Katowice, Poland

Wojciech Rutkowski

ORCID 0009-0004-7393-4231

<https://orcid.org/0009-0004-7393-4231>; [worutkowski@gmail.com](mailto:worutkowski@gmail.com)

Leszek Giec Upper-Silesian Medical Centre of the Silesian Medical University in Katowice  
ul. Ziołowa 45 / 47, 40-635 Katowice

Maciej Rzepka

ORCID 0009-0009-9005-817X

<https://orcid.org/0009-0009-9005-817X>

ST. BARBARA SPECIALIZED REGIONAL HOSPITAL No.5,  
Medyków Square 1, 41-200 Sosnowiec, POLAND

Karolina Sztuba

ORCID 0000-0003-4987-3833

<https://orcid.org/0000-0003-4987-3833>

SPZOZ District Railway Hospital in Katowice

Corresponding author

Natalia Gajdzińska

ORCID 0009-0009-1072-2895

<https://orcid.org/0009-0009-1072-2895>; [gajdzinska.natalia@gmail.com](mailto:gajdzinska.natalia@gmail.com)

Independent Public Health Care Institute of the Ministry of Internal Affairs and Administration in Katowice,  
ul. Wita Stwosza 41, 40-514 Katowice, Poland

**Abstract**

Hypothyroidism refers to the common pathological condition of thyroid hormone deficiency. Multiple studies have concluded that undiagnosed and undertreated patients with hypothyroidism are at increased risk of developing mental disorders. Moreover, there are proven cases of symptom remission with or without antidepressants after a euthyroid state was established. Studies suggest that exercise can have positive effects on thyroid function as well as improving mental state. However, patients with untreated hypothyroidism often experience decreased exercise tolerance, weakness, fatigue, and feelings of low energy, which often prevent them from engaging in physical activities. This review strengthens the link between hypothyroidism, mental health issues and struggles that come with thyroid hormone deficiency and physical activity. It also demonstrates how treating the underlying hypothyroidism, as well as promoting regular physical activity, can be significant ways to improve health outcomes in these patients.

**Methods**

A systematic literature search was conducted using PubMed and Google Scholar data bases, focusing on studies published in English and Polish that examined the relationship between untreated hypothyroidism, mental health disorders, and engaging in regular physical activities. Keywords included "untreated hypothyroidism," "mental illness," "depression," "anxiety," "exercise tolerance," and "quality of sleep".

**Aim of the study:**

The aim of our work is to review and summarize the most interesting conclusions from the research on the impact of hypothyroidism on developing mental disorders as well as outcomes on physical activity performance.

**Key words**

Hypothyroidism, depression, anxiety, physical activity, quality of sleep, mental disorders

## **Introduction**

The thyroid gland maintains an optimal level of metabolism in various tissues for their proper functioning. The main hormones secreted by the thyroid are thyroxine (T4) and triiodothyronine (T3). Hypothyroidism refers to the common pathological condition of thyroid hormone deficiency, which among adults often manifests in a reduced basal metabolic rate, cold intolerance, weight gain, constipation, dry skin, slow speech, slower cognitive processes, impaired memory, and severe mental disorders, but clinical presentation can differ with age and sex, among other factors. Untreated patients may also report experiencing reduced exercise tolerance, low mood, and decreased energy levels.

### **Importance of diagnosing hypothyroid among patients with mental diseases**

Common symptoms of psychological dysfunction encountered in hypothyroidism include forgetfulness, mental slowness, lethargy and emotional lability. [1] Hypothyroidism even when occult or subclinical can cause changes in energy, mood, anxiety level or cognition. Antidepressants and mood stabilizers appear not to be as effective in patients with abnormal thyroid function. [2] Levothyroxine therapy is known to improve the symptoms of depression rapidly when compared to antidepressants alone. [3] Both increase and decrease in thyroid function can cause mood abnormalities. [4] Recognizing and correcting hypothyroidism by adequate treatment, including subclinical presentations, can alleviate symptoms similar to those of affective disorders. [2]

### **Most common mental diseases among patients with hypothyroidism**

#### **Depression**

Many studies support the association between hypothyroidism and depression. A vast body of research demonstrated that somatostatin and serotonin influence the hypothalamus-pituitary-thyroid axis. There is also a possible association between autonomic mechanisms involving the thyroid gland and depressive disorders, but the available evidence is so far not clear. However, studies demonstrate that antithyroid antibodies are elevated among many people with depression. [3] Hypothyroid patients usually tend to experience concentration difficulties, lassitude, low libido, and pessimism or sadness that can be linked with major depressive episodes. [2] Thyroid hormones not only participate in the pathophysiology of depression, but also influence the development of psychotic symptoms. [5] Studies show that subclinical hypothyroidism is also highly correlated with major depressive disorder. [6] The treatment protocol usually entails the treatment of hypothyroidism appropriately with thyroid

replacement therapy and antidepressants. Levothyroxine functions to improve the action of antidepressants, potentiating their effects in treating and improving the symptoms of depression. [3] In addition it is important to remember that the endocrine system presents different features throughout a lifetime and age may significantly influence in thyroid function's role in depression with psychotic symptoms. [5]

#### Bipolar affective disorder

One of the most common mental illness associated with hypothyroidism is depression. However, an increasing number of scientific articles are highlighting the important role of thyroid hormone deficiency among patients who suffer from bipolar affective disorder. Mood disorders are intimately associated with suboptimal thyroid function. [7] Studies from 2014 done by Dr. Bindu Menon from the Department of Psychiatry in India showed a significant correlation between a family history of mood disorder in the first degree relatives and patients with hypothyroidism. [8] Moreover, studies done in 2016 also suggested a possible correlation in thyroid antibodies among possible endophenotypes for bipolar disorder. [9] A recent large sample sized cross-sectional study in China shown a correlation between decreased serum FT4 level a high prevalence of psychotic depression among depression adolescents and recommended that adolescents with depressive disorders regularly screen their serum FT4 levels for better clinical outcomes. [5]

#### Poor sleep quality

Studies show poor sleep can trigger mania, psychosis or paranoia, as well as make existing symptoms worse. Hypothyroidism may affect overall sleep quality. Although no direct biochemical connection has been established between hypothyroidism and insomnia, some studies have shown a relationship between untreated subclinical hypothyroidism and poor sleep quality. [10]

#### Anxiety

Although anxiety is usually associated with hyperthyroidism, studies show that occasionally this type of disorder may also be observed among patients with T3 and T4 deficiency. The symptoms include panic disorder, agoraphobia, social phobia, performance anxiety, post-traumatic stress disorder and generalized anxiety disorder.[2]

#### **The beneficial role of physical activity in mental health**

Numerous epidemiological studies have demonstrated the beneficial role of physical activity in healthy living and preventing many disorders. Adequate exercise is proven to lower physical conditions such as cardiometabolic illness, breast and colon cancer, osteoporosis, obesity. Regular activity is associated not only with lower risk of developing mental health

problems but is also a promising way to manage them. Exercise has been evaluated as an adjunct intervention for mood disorders including major depressive disorder and bipolar disorder. [11], [12] Neuroplasticity is increasingly characterized as a central mechanistic component of mental health improvements and is highly influenced by physical activity. [11] Neuroplasticity is the brain's ability to reorganize itself by forming new neural connections throughout life. It is an ongoing process that allows the neurons in the brain to compensate for injury and disease and to adjust their activities in response to new situations or changes in the environment. Neuroplasticity also plays a crucial role in learning and memory. Increased neuroplastic capacity is one hypothesized mechanism underlying the mental health benefits of several widely used somatic psychiatric treatment modalities. Exercise is one of the few behavioral processes that appears to increase neuroplasticity. [11]

### **Regular physical activity in hypothyroidism**

Decreased exercise tolerance is a common symptom among people with hypothyroidism, as well as weakness, fatigue, and feelings of low energy. Therefore, for untreated patients, exercising regularly can be more challenging and less appealing compared to the rest of the population. Recent studies showed a strong association between the amount of daily physical activity of American adults and changes in thyroid function, including thyroid hormone levels and thyroid diseases. [13] People with hypothyroidism engage in sports less frequently, which may be due to the influence of hypothyroidism on the lungs, heart and muscles, which can cause impaired exercise tolerance. [14] Hypothyroidism results in increased vascular resistance, decreased cardiac output, decreased left ventricular function, and changes in several other markers of cardiovascular contractility. [15] However, due to a lack of physical activity, there is a higher risk for patients with hypothyroidism of developing mental disorders, to which they are already more susceptible compared to the general population. Studies from 2021 has uncovered several novel factors that are associated with exercise intolerance in patients with hypothyroidism. Main reported long-term physical activity limitations among participants were muscle pain, fatigue after exercise and arthralgia. Two-thirds of the respondents indicated that their current condition of hypothyroidism limited their physical activity performance. [16] Surprisingly, other studies, also done in 2021, showed that more patients engaged in sports activities compared to the general population. However, two-thirds of the patients indicated that the current condition of hypothyroidism was limiting their physical activity performance. [17]

### **Discussion**

Research shows a strong association between the occurrence of mental illnesses and undiagnosed hypothyroidism. Clinical symptoms of hypothyroidism can also be notoriously variable. The degree of impairment may depend on the patient's normal functional level. [2] . In addition, symptoms often overlap, which can cause problems with diagnosing patients as

well as removing the source of the underlying issue. On the other hand, there is a risk that individuals suffering from psychiatric disorders may overly attribute low mood to diagnosed hypothyroidism and not seek help for their mental health.

## **Conclusion**

There is a proven association between developing mental disorders and patients with hypothyroidism. There are also described cases demonstrating a significant remission in symptoms among patients after their euthyroid state was established. Healthcare providers should consider routine screening for thyroid dysfunction in patients presenting with psychiatric symptoms. In addition, one proven beneficial way to improve mental state is regular exercise, but as mentioned earlier, due to reduced exercise tolerance and lack of quality sleep, it can be more challenging and not as appealing for people with untreated hypothyroidism. Further research is needed to establish proper therapeutic guidelines and strengthen the link between hypothyroidism, mental disorders, and challenges in engaging in regular physical activities.

Authors contribution:

Conceptualization: Karolina Basiura, Dominika Starzomska

Methodology: Karolina Basiura, Katarzyna Rymaszewska,

Software: Maciej Rzepka, Adam Salwa, Karolina Basiura,

Check: Natalia Gajdzińska, Justyna Puchała

Formal Analysis: Adam Salwa, Katarzyna Rymaszewska

Investigation: Karolina Basiura, Dominika Starzomska

Resources: Dominika Starzomska, Justyna Puchała, Natalia Gajdzińska

Data curation: Karolina Basiura, Weronika Rostkowska, Adam Salwa

Writing- rough preparation: Karolina Basiura, Natalia Gajdzińska,

Writing- review and editing: Wojciech Rutkowski, Karolina Sztuba, Karolina Basiura

Visualization: Karolina Basiura, Katarzyna Rymaszewska

Supervision: Karolina Sztuba, Dominika Starzomska, Maciej Rzepka, Adam Salwa,

Project administration: Karolina Basiura

Receiving funding: no funding was received.

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

Funding statement: No financial support was received.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Our work did not involve direct human subject research or obtaining their consent for participation in the study.

Data Availability Statement: Since this is a review paper, our work does not contain new data or analyses. Consequently, there are no databases or data accessibility to outline. The details and conclusions presented in this review are derived from previously published studies, which can be accessed through their respective sources as mentioned in the references section.

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

## References

- [1] A. Sathya, R. Radhika, S. Mahadevan, and U. Sriram, "Mania as a presentation of primary hypothyroidism," *Singapore Med. J.*, vol. 50, no. 2, pp. 2–4, 2009.
- [2] T. D. Geraciotti, "Identifying hypothyroidism's psychiatric presentations," no. November 2006, 2018.
- [3] S. P. Nuguru, S. Rachakonda, S. Sripathi, M. I. Khan, N. Patel, and R. T. Meda, "Hypothyroidism and Depression: A Narrative Review," *Cureus*, vol. 14, no. 8, pp. 10–17, 2022, doi: 10.7759/cureus.28201.
- [4] M. Bathla, M. Singh, and P. Relan, "Prevalence of anxiety and depressive symptoms among patients with hypothyroidism," *Indian J. Endocrinol. Metab.*, vol. 20, no. 4, pp. 468–474, 2016, doi: 10.4103/2230-8210.183476.
- [5] R. Yang *et al.*, "Association between thyroid function and psychotic symptoms in adolescents with major depressive disorder: A large sample sized cross-sectional study in China," *Heliyon*, vol. 9, no. 6, p. e16770, 2023, doi: 10.1016/j.heliyon.2023.e16770.
- [6] M. Li, X. W. Wang, X. Q. Wang, J. J. Zhang, and X. Y. Zhang, "Prevalence and risk factors for subclinical hypothyroidism in older patients with major depressive disorder," *BMC Geriatr.*, vol. 24, no. 1, pp. 1–8, 2024, doi: 10.1186/s12877-023-04584-9.
- [7] S. Chakrabarti, "Thyroid functions and bipolar affective disorder," *J. Thyroid Res.*, vol. 2011, 2011, doi: 10.4061/2011/306367.
- [8] B. Menon, "Hypothyroidism and bipolar affective disorder: Is there a connection?," *Indian J. Psychol. Med.*, vol. 36, no. 2, pp. 125–128, 2014, doi: 10.4103/0253-7176.130966.
- [9] A. Bocchetta, F. Traccis, E. Mosca, A. Serra, G. Tamburini, and A. Loviselli, "Bipolar disorder and antithyroid antibodies: review and case series," *Int. J. Bipolar Disord.*, vol. 4, no. 1, pp. 1–18, 2016, doi: 10.1186/s40345-016-0046-4.
- [10] M. E. Green, V. Bernet, and J. Cheung, "Thyroid Dysfunction and Sleep Disorders," *Front. Endocrinol. (Lausanne)*, vol. 12, no. August, pp. 10–13, 2021, doi: 10.3389/fendo.2021.725829.
- [11] Trier AM, Mack MR, Kim BS. The Neuroimmune Axis in Skin Sensation, Inflammation, and Immunity. *J Immunol.* 2019 May 15;202(10):2829-2835. doi: 10.4049/jimmunol.1801473. PMID: 31061146; PMCID: PMC6563610. doi: 10.4049/jimmunol.1801473.
- [12] Y. Wang and K. Ashokan, "Physical Exercise: An Overview of Benefits From Psychological Level to Genetics and Beyond," *Front. Physiol.*, vol. 12, no. August, pp. 10–13, 2021, doi: 10.3389/fphys.2021.731858.
- [13] L. Tian, C. Lu, and W. Teng, "Association between physical activity and thyroid function in American adults: a survey from the NHANES database," *BMC Public Health*, vol. 24, no. 1, pp. 1–15, 2024, doi: 10.1186/s12889-024-18768-4.
- [14] K. Schok, J. Jasek, K. Wiejak, K. Skoczylas, J. Mikulska, and S. Rokicki, "The relationship between



- hypothyroidism and physical exercise: impact on exercise tolerance and health,” *J. Educ. Heal. Sport*, vol. 35, no. 1, pp. 160–172, 2023, doi: 10.12775/jehs.2023.35.01.012.
- [15] L. Chaker, A. C. Bianco, J. Jonklaas, and R. P. Peeters, “Hypothyroidism,” *Lancet*, vol. 390, no. 10101, pp. 1550–1562, 2017, doi: 10.1016/S0140-6736(17)30703-1.
- [16] J. A. C. Lankhaar, E. Kemler, J. H. Stubbe, and F. J. G. Backx, “Physical Activity in Women With Hypothyroidism on Thyroid Hormone Therapy: Associated Factors and Perceived Barriers and Benefits,” *J. Phys. Act. Health*, vol. 18, no. 11, pp. 1383–1392, 2021, doi: 10.1123/jpah.2021-0230.
- [17] J. A. C. Lankhaar *et al.*, “Physical activity, sports participation and exercise-related constraints in adult women with primary hypothyroidism treated with thyroid hormone replacement therapy,” *J. Sports Sci.*, vol. 39, no. 21, pp. 2493–2502, 2021, doi: 10.1080/02640414.2021.1940696.
- [18] B. Biondi, “Treatment of hypothyroidism,” *Encycl. Endocr. Dis.*, vol. 8, no. 12, pp. 624–626, 2018, doi: 10.1016/B978-0-12-801238-3.04164-7.
- [19] D. Wojtachnio, A. Osiejewska, J. Bartoszewicz, and A. Grądzik, “Hypothyroidism: clinical presentation, diagnosis, treatment,” vol. 12, no. 8, pp. 650–660, 2022.
- [20] S. Katarzyna *et al.*, “The journal has had 7 points in Ministry of Science and Higher Education parametric evaluation,” *J. Educ.*, vol. 6, no. 7, pp. 2391–8306, 2016, [Online]. Available: <http://dx.doi.org/10.5281/zenodo.58447>
- [21] K. Vasyl, "Correction of students negative states by health fitness means as a scientific problem." Vasyl Khlopetskyi, Serhii Kuryliuk Vasyl Stefanyk Precarpathian National University, vol. 7, no. 2, pp. 859–870, 2017.
- [22] Kujawska A, Perkowski R, Androsiuk-Perkowska J, Skierkowska N, Gajos M, Topka W, Kujawski S, Kędziora-Kornatowska K. Physical activity in healthy, older people. How many drops of sweat away from gain the health benefit?. *J Educ Health Sport* [Internet]. 2017 Jul. 23 [cited 2024 Jul. 12];7(7):412-2. Available from: <https://apcz.umk.pl/JEHS/article/view/4640>
- [23] P. Mindfulness, “Mindfulness and Movement: Scientifically Exploring the Health Impacts of Yoga Martyna Kuśmierska ORCID: <https://orcid.org/0009-0005-5895-2471> Independent Public Health Care Facility, Municipal Hospital Complex in Chorzów, 11 Strzelców Bytomskich Stree,” pp. 206–220, 2024.
- [24] N. Kusari, D. Sukova-Stojmanovska, and A. Elezi, “Correlation of body composition with depression level,” *J. Educ. Heal. Sport*, vol. 10, no. 11, pp. 104–113, 2020, doi: 10.12775/jehs.2020.10.11.011.
- [25] W. Szpital, P. Medyków, W. Szpital, and P. Medyków, “The influence of sport climbing on depressive disorders Sara Rosołowska-Żak; 41-200 Sosnowiec, Poland. Patrycja Paschke; ORCID 0009-0006-0306-3332; SP ZOZ MSWiA w Katowicach im. Sierżanta Grzegorza Załogi Ul. Wita Stwosza 41, 40-514 Katowice. Pola,” no. 32553, pp. 1–15, 2024.
- [26] Kaźmierczak U, Radziwińska A, B. I. Dzierżanowski M., Strojek K., Srokowski G, and Zukow W., “Korzyści z podejmowania regularnej aktywności fizycznej przez osoby starsze The benefits of regular physical activity for the elderly,” vol. 5, no. 1, pp. 56–68, 2015, doi: 10.5281/zenodo.13935.
- [27] A. Gałuszka, “Planowanie aktywności ruchowej oraz korzyści z niej płynące u osób po 60. roku życia,” *J. Educ. Heal. Sport*, vol. 12, no. 6, pp. 118–129, 2022, doi: 10.12775/jehs.2022.12.06.012.
- [28] J. Qin, J. Yao, and L. Teng, “The Effect of Physical Activity on the Non-cognitive Ability of

- Adolescents,” *Qual. Sport*, vol. 9, no. 2, pp. 59–70, 2023, doi: 10.12775/qs.2023.09.02.007.
- [29] B. Dwojaczny and M. Bejtka, “Influence of physical activity on cognitive functions - Potential mechanisms and benefits,” *J. Educ. Heal. Sport*, vol. 13, no. 3, pp. 181–185, 2023, doi: 10.12775/jehs.2023.13.03.026.
- [30] M. Łakomski, J. Pietsch, J. Chłystek, A. Abramczyk, A. Golus, and W. Żukow, “The effect of physical activity on mood - a review of current literature,” *J. Educ. Heal. Sport*, vol. 7, no. 4, pp. 807–815, 2017, [Online]. Available: <http://repozytorium.umk.pl/handle/item/4819>
- [31] A. Metelski, “Physical activity in Poland and the European Union,” *Qual. Sport*, vol. 5, no. 3, pp. 7–21, 2019, doi: 10.12775/qs.2019.013.
- [32] M. Sambura *et al.*, “Sport impact on patients with psoriasis and psychiatric Abstract Introduction : Psoriasis is a systemic inflammatory disease with an immunological basis. The estimated number of people suffering from psoriasis is 60 million. Despite the large number of ,” no. 4, pp. 1–13, 2024.
- [33] K. Piotrowska and Ł. Pabianek, “Physical activity – classification, characteristics and health benefits,” *Qual. Sport*, vol. 5, no. 2, pp. 7–14, 2019, doi: 10.12775/qs.2019.007.
- [34] P. J. Smith and R. M. Merwin, “The Role of Exercise in Management of Mental Health Disorders: An Integrative Review,” *Annu. Rev. Med.*, vol. 72, pp. 45–62, 2021, doi: 10.1146/annurev-med-060619-022943.
- [35] A. Mahindru, P. Patil, and V. Agrawal, “Role of Physical Activity on Mental Health and Well-Being: A Review,” *Cureus*, vol. 15, no. 1, pp. 1–7, 2023, doi: 10.7759/cureus.33475.
- [36] J. Cracraft, “It is time to move on from homology in comparative biology,” *J. Morphol.*, vol. 284, no. 1, pp. 177–184, 2023, doi: 10.1002/jmor.21530.