DOI: 10.4274/tjcd.galenos.2025.2025-2-5
Turk J Colorectal Dis 2025;35(2):55-58

RESEARCH ARTICLE

The Relationship Between Sweat Response, BMI, and Physical Activity: Implications for Pilonidal Sinus Disease

Dietrich Doll[1,2,*], Jannik Seifert[1,2], Imke Brengelmann[1,2], Maximilian Kuntze[3], PiloNERDs*

[1]St. Marienhospital Vechta, Academic Teaching Hospital of the MHH, Clinic of Procto-Surgery, Vechta, Germany
[2]Vechtaer Research Institute VIFF e.V., Vechta, Germany
[3]University of Vechta, Health Sciences, Vechta, Germany
*Pilonidal Network for Expertise, Research and Development (PiloNERDs International)

ABSTRACT

Aim: Obesity has been suspected of influencing sweating and constituting a risk factor for pilonidal sinus disease (PSD), given the parallel rise in both obesity and PSD incidence in developed countries. This study, therefore, examined the relationship between sweating and body mass index (BMI).

Methods: A total of 322 individuals from a large northern German cohort, all without PSD, were assessed. A questionnaire was designed to evaluate BMI and engagement in sports activities. Standardized pilocarpine iontophoresis sweat testing was performed in the glabella sacralis region, 5-10 cm cephalad to the intergluteal fold.

Results: The normal BMI group had significantly higher sweat production (20.74±2.5 µl) than the high BMI group (17.10±2.8 µl) ($p<0.001$). Individuals who regularly participated in sports more than twice a week exhibited significantly higher sweat production than those who did not exercise (27.2±2.9 µl vs. 24.4±1.6 µl, $p<0.001$).

Conclusion: Increased BMI was not associated with increased pilocarpine iontophoresis-induced glabella sacralis sweat output. Engagement in sports increased sweat production in both normal and high BMI individuals. Increased sweating may play a protective role, potentially contributing to weight reduction and, consequently, a lower incidence of PSD through mechanisms yet to be elucidated.

Keywords: BMI, obesity, inactivity, sports, sweat, intergluteal, moisture, hair, pilonidal sinus, hair strength, hair force, incidence

Introduction

Pilonidal sinus disease (PSD) is an acute or chronic infection of the subcutaneous tissue caused by the penetration of sharply cut hair fragments into the upper intergluteal fold. This condition necessitates more than 30,000 surgical interventions annually in Germany, predominantly affecting young men and women. Its incidence has been rising in both military and civilian populations.[1]

An increasing prevalence of PSD has long been suspected. Karydakis documented a rise in the proportion of Greek army recruits affected by PSD, from 4.9% in 1960 to 25.8% in 1974, with further increases to 30%-33% by 1992.[2] Hair penetration into the skin generally occurs during a "vulnerable time window" around puberty,[3,4] with symptom onset thought to be facilitated by sweating and repetitive mechanical stress.[5,6] The reasons for the worldwide increase in PSD remain unclear. Although poor hygiene was previously, but incorrectly, implicated,[7] the substantial presence of sharp hair fragments in the lumbar region immediately following haircuts may be a contributing factor,[8] particularly in military environments where short haircuts are mandatory.[1,6,9,10]

Over the past three decades, increased sweating due to obesity has been considered a potential risk factor for PSD. However, studies have paradoxically shown decreased sweat production

Address for Correspondence: Dietrich Doll MD, St. Marienhospital Vechta, Academic Teaching Hospital of the Medical School, Department of Procto-Surgery, Hannover, Vechta, Germany
E-mail: piloNERDs@gmail.com **ORCID ID:** orcid.org/0000-0001-9832-4545
Received: 25.02.2025 **Accepted:** 11.06.2025 **Publication Date:** 27.06.2025

Cite this article as: Doll D, Seifert J, Brengelmann I, Kuntze M. The relationship between sweat response, bmi, and physical activity: implications for pilonidal sinus disease. Turk J Colorectal Dis. 2025;35(2):55-58

in patients with PSD.[11]Nevertheless, obesity remains high on the list of suspected contributing factors. Given the global rise in obesity, PSD has been increasingly observed in so-called developed (well-nourished) countries. Despite the widespread assumption of an association, only one study has provided robust epidemiological evidence linking obesity to PSD. At the University of Minnesota, Cowan (as cited by Dwight in 1953) assessed 30,480 men, demonstrating that those without PSD had an average weight of 103% of normal, whereas the 355 students diagnosed with PSD had an average weight of 109% of normal ($p<0.001$).[12]

The objective of this study was to investigate whether obesity is associated with decreased sweat production, which, if confirmed, might suggest a link between obesity and PSD. The study hypothesis (Hα) posited that obesity leads to a reduction in sweat production, independent of sports activity.

Materials and Method

All procedures performed in studies involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This study did not include any interventions that could cause harm to human participants. Informed consent was obtained from all participants prior to sweat testing. Ethical approval was granted in advance through formal application to and approval by the Institutional Review Board of the Ärztekammer Hannover (approval number:BO/33/2016, dated 08.122016).

Sweat testing was conducted in a cohort of healthy individuals from northern Germany, aged 5 to 79 years, including 332 participants aged 16 years or older. Individuals were excluded from the study if they had thyroid disease, muscular disorders, were underweight or had cachexia, pain exceeding 3 on the Visual Analogue Scale,[13, 14] or any conditions associated with known or suspected disturbances in temperature regulation or fluid balance, such as fever, renal disease, ileus, dehydration, or endocrine disorders. Additionally, individuals receiving diuretic therapy were deemed ineligible.

Participants were classified according to the World Health Organization (WHO) criteria for body weight as follows:

- Category 0: Underweight, with a body mass index (BMI) below 18.5 kg/m^2.
- Category 1: Normal weight, with a BMI between 18.5 kg/m^2 and <25 kg/m^2.
- Category 2: Overweight, with a BMI of 25 kg/m^2 and above.[15]

In Category 2, BMI ranges of WHO-defined pre-obese individuals and those with class I–III obesity were combined. Although waist circumference is recognized as a reliable indicator of intra-abdominal fat deposits and cardiovascular risk,[16] it was not utilized in this study due to its limited accuracy in assessing body weight-related exertion, as it does not account for height and associated weight.[16]

Sweat Test

Sweat testing was performed as previously described.[11,17] In summary, the procedure was conducted as follows:

The Macroduct Sweat Collection System (Webster Sweat Inducer, iontophoresis electrodes, SS-032G pilocarpine gel discs, and sweat-collecting device; Kreienbaum Neoscience GmbH, Langenfeld, Germany) was used, ensuring standardized sweat collection across all participants. The test area was restricted to the lumbar region, with the red electrode positioned midway between the fossae sacrales (Figure 2). To avoid alterations in skin perfusion, alcohol swabs were not used for skin preparation.

Sweat production was induced via pilocarpine iontophoresis, with the red electrode placed on the glabella sacralis and the black electrode positioned approximately one fingerbreadth above. A Webster sweat inducer (model 3700) delivered a constant iontophoretic current of 1.5 mA for five minutes. Pilocarpine was administered through reagent-impregnated (0.5% pilocarpine) solid agar gel discs (Pilogel® discs). This method is recognized as a reliable and standardized approach for inducing sweat production and is widely used for sweat stimulation and collection, including in neonates for the diagnosis of cystic fibrosis.[18-20]

Sweat was collected for 15 minutes following standardized iontophoretic stimulation using a Macroduct sweat collector. The volume of sweat collected was determined by measuring the length of the fixed-diameter plastic tube filled with sweat using the standardized Macroduct scale. Immediately after removal of the Macroduct sweat collection system from the pilocarpine-stimulated skin area, any residual fluid at the contact site was absorbed using a pre-weighed dry swab. The swab was then weighed using a wind-shielded Sartorius scale (model 1201 MP2, Sartorius). The weight of the swab plus the absorbed fluid was added to the volume collected via the Macroduct system, and all measurements were documented in Excel (Microsoft Office Package 2003, Microsoft Corp., Richmond, USA).

Statistical Analysis

To assess differences in sweat response between BMI groups and levels of sports activity, statistical analyses were performed using an independent t-test. This test was applied to compare the mean sweat response between normal-weight and overweight individuals across varying activity levels. A p-value of <0.05 was considered statistically significant.

Results

There were 148 participants in BMI Group 1 and 184 participants in BMI Group 2. Across all individuals, the total average sweat response was 18.5±2.6 µl. The normal-weight group exhibited a higher overall sweat response, with a mean of 20.74±2.5 µl, compared with 17.10±2.8 µl in the overweight group ($p<0.001$) (Table 1).

In the absence of sports participation, the sweat response was similar between normal-weight (16.84±1.3 µl) and overweight individuals (15.95±1.4 µl) ($p=0.238$). Among those engaging in sports once a week, the sweat response increased to 17.69±1.2 µl in the normal-weight group and 18.74±1.6 µl in the overweight group ($p=0.825$). For individuals participating in sports more than twice a week, the difference was significant, with normal-weight individuals showing a sweat response of 27.70±2.9 µl compared with 24.47±1.6 µl in the overweight group ($p<0.001$) (Table 1).

Discussion

This analysis demonstrates that sweat response is substantially influenced by both BMI and physical activity levels. Although overweight individuals exhibit greater sweat production at rest and during low-intensity activity, normal-weight individuals demonstrate a more pronounced increase in sweat response with higher levels of physical exertion. This suggests that thermoregulatory efficiency is optimized in normal-weight individuals, whereas overweight individuals may experience physiological constraints in sweat gland activation and heat dissipation during intense exercise. Further research is warranted to evaluate the impact of hydration status, environmental factors, and long-term training adaptations on sweat response across different BMI categories.

Although the data suggest that normal-weight individuals tend to exhibit a slightly higher sweat response, particularly with increased physical activity, statistical analysis confirms that this difference is not sufficiently robust to be deemed substantial. Conversely, overweight individuals display consistently high sweat responses across all levels of activity; however, their peak sweat output does not surpass that of the normal-weight group in a meaningful manner. These findings imply that BMI alone is not a major determinant of sweat response.

The data presented in the table highlight a clear correlation between sports participation and sweat response, with a general trend of increased sweat production as the frequency of sports activity rises. Individuals engaging in sports more than twice per week demonstrate the highest sweat response within both normal-weight and overweight groups. This suggests that regular physical activity enhances the body's ability to produce sweat, likely as a thermoregulatory adaptation to exercise.

Regarding sweat response and sports frequency, a higher sweat response is observed with increased sports participation: both normal-weight and overweight individuals who engage in sports more than twice per week exhibit the highest sweat output (27.70 µl for normal-weight individuals and 24.47 µl for overweight individuals). Those participating once or twice per week show a moderate increase in sweat response compared with non-athletes.

There is a consistently high sweat response in overweight individuals: sweat production in this group remains relatively elevated across all levels of sports participation, suggesting that higher body mass contributes to greater baseline sweating, potentially due to increased heat production. However, their capacity to further increase sweat response with higher physical activity is less pronounced than in normal-weight individuals, indicating potential limitations in thermoregulatory efficiency.

A dynamic sweat response is observed in normal-weight individuals: the most substantial increase in sweat production with rising sports participation occurs in this group, suggesting a more efficient sweating mechanism as fitness levels improve. This supports the concept that individuals with higher physical conditioning develop more responsive sweat gland function, thereby enhancing their ability to regulate body temperature effectively. These findings align with existing literature, which suggests that sports participation and physical activity substantially enhance sweat production as part of the body's adaptation to exercise. Studies have shown that regular exercise increases sweating capacity by improving sweat gland activity and initiating earlier sweat onset. Highly trained athletes tend to sweat more and at lower core temperatures than untrained

Table 1. Pilocarpine-induced sweating (µl) in northern German healthy volunteers aged ≥16 (n = 332), cross-table for body weight versus sports activity

Level of sports activity	Total sweat response (n)	BMI group 1 (normal weight) (n)	BMI group 2 (overweight) (n)	p
1: No sports	15.95±1.4 (144)	16.84±1.3 (45)	15.95±1.4 (99)	0.238
2: Sport once or twice a week	17.89±1.3 (110)	17.69±1.2 (54)	18.74±1.6 (56)	0.825
3: More than twice a week	24.47±2.2 (78)	27.20±2.9 (49)	24.47±1.6 (29)	<0.001
Total	18.57±2.6 (332)	20.74±2.5 (148)	17.10±2.8 (184)	<0.001

BMI: Body mass index

individuals, enabling more effective thermoregulation during intense exercise. Thus, higher fitness levels correlate with a greater sweat response, consistent with the data presented in this study, where normal-weight individuals engaging in frequent sports activity demonstrate the most substantial increase in sweat response.

Obesity is associated with elevated sweat rates at rest and during low-intensity activities. However, studies suggest that overweight individuals may not enhance their sweating as effectively during intense physical activity compared with trained individuals. This may be attributed to lower overall fitness levels, reduced sweat gland efficiency, and a greater reliance on alternative heat dissipation mechanisms, such as increased cutaneous blood flow. Nonetheless, any form of physical training, regardless of intensity or body weight, has the potential to enhance sweat production. This finding has implications not only for personal fitness and physiological well-being but also for the potential prevention of PSD.

The present study has certain limitations. The sample size is of moderate scale, and the cohort of normal-weight participants is representative of the typical behavior and physiological responses observed in a northern German population. However, variations in activity levels, sweating responses, BMI, and other physiological parameters may differ substantially across populations in Mediterranean, sub-Saharan, and Asian regions, where climate, dietary patterns, and lifestyle habits vary considerably.

Conclusion

This study indicates that sports participation plays a crucial role in enhancing sweat response. Although overweight individuals tend to exhibit a higher baseline sweat output, their ability to further increase sweating during intense exercise appears somewhat constrained compared with normal-weight individuals. These findings suggest that fitness level, rather than BMI alone, serves as a more substantial determinant of an individual's sweat response and thermoregulatory efficiency during physical activity.

Ethics

Ethics Committee Approval: Ethical approval was granted in advance through formal application to and approval by the Institutional Review Board of the Ärztekammer Hannover (approval number: BO/33/2016, dated: 08.122016).

Informed Consent: Informed consent was obtained from all participants prior to sweat testing.

Footnotes

Authorship Contributions

Surgical and Medical Practices: D.D., I.B., Concept: D.D., I.B., Design: D.D., I.B., Data Collection or Processing: D.D., M.K., Analysis or Interpretation: D.D., J.S., MK., Literature Search: D.D., J.S., MK. Writing: D.D., J.S., MK.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Evers T, Søreide K, Matthiessen P, Isaksson K, Doll D. Trends in incidence and long-term recurrence rate of pilonidal sinus disease and analysis of associated influencing factors. Zhonghua Wai Ke Za Zhi. 2011;49:799-803.
2. Karydakis GE. Easy and successful treatment of pilonidal sinus after explanation of its causative process. Aust N Z J Surg. 1992;62:385-389.
3. Doll D, Matevossian E, Dettmann H, Evers T, Luedi MM. Time and rate of sinus formation in pilonidal sinus disease. Int J Colorectal Dis. 2007;23:359-364.
4. Ardelt M, Luedi MM, Wieferich K, Hoffmann S, Doll D. Puberty is a major factor in pilonidal sinus disease: Gender-specific investigations of case number development in Germany from 2007 until 2015. Chirurg. 2017;88:961-967.
5. Patey D. Pilonidal sinus—or 'jeep disease'. Nurs Times. 1971;67:534-536.
6. Akinci OF, Bozer M, Uzunköy A, Düzgün SA, Coşkun A. Incidence and aetiological factors in pilonidal sinus among Turkish soldiers. Eur J Surg. 1999;165:339-342.
7. Doll D, Luedi MM, Evers T, Matevossian E, Ommer A. Stop insulting the patient: neither incidence nor recurrence in pilonidal sinus disease is linked to personal hygiene. Pilonidal Sinus J. 2015;1:8.
8. Doll D, Luedi MM, Wysocki A, Petersen S. Immediate cut hair translocation to the intergluteal fold in the hairdressers shop – another link to pilonidal sinus disease. Pilonidal Sinus J. 2019;5:23-32.
9. Fabre A, Delattre JF, Legre A. Technic for simple and radical treatment of sacrococcygeal fistulas and cysts. Presse Med. 1961;69:771.
10. Karydakis G. The problem of pilonidal cyst in the Greek Armed Forces. Hell Arm Forces Med Rev. 1973;7:512-520.
11. Doll D, Luedi MM, Wysocki A, Reinshagen S, Petersen S. Rethinking the causes of pilonidal sinus disease: a matched cohort study. Sci Rep. 2021;11:1-7.
12. Dwight RW, Maloy JK. Pilonidal sinus; experience with 449 cases. N Engl J Med. 1953;249:926-930.
13. Hayes MHS, Paterson DG. Experimental development of the graphic rating method. Psychol Bull. 1921;18:98-99.
14. Freyd M. The graphic rating scale. J Educ Psychol. 1923;14:83-102.
15. World Health Organization. Weight Scale [Internet]. 2018 [cited 2018 Aug 29). Available from: http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi
16. Lean ME. Pathophysiology of obesity. Proc Nutr Soc. 2000;59:331-336.
17. Izbicki J. Die Schweißrate in Relation zur Haarsteifigkeit in der norddeutschen Normalbevölkerung im Vergleich zu Pilonidalsinus-Patienten. In: Universitätsklinik Homburg (Saar), Allgemein-, Viszeral- und Kinderchirurgie. Homburg/Saar: Saarland University; 2022. p. 1-69.
18. Shwachman H, Mahmoodian A. Pilocarpine iontophoresis sweat testing results of seven years' experience. Bibl Paediatr. 1967;86:158-182.
19. Warren RH, Jones B, Heffington R. Diagnostic testing in cystic fibrosis. J Ark Med Soc. 1983;79:451-454.
20. Barnes GL, Vaelioja L, McShane S. Sweat testing by capillary collection and osmometry: suitability of the Wescor Macroduct System for screening suspected cystic fibrosis patients. Aust Paediatr J. 1988;24:191-193.