ISSN 2639-8109 | Volume 15

Annals of Clinical and Medical Case Reports®

Case Report Open Access

Pine Pollen Impacts Hypogonadal Symptoms in Younger Men with Variations in Androgen Levels: Pilot Observations

Gerald M Haase[1*], Neil E Wolkodoff[2], Stacy G Beal[3], Robert M Mordkin[4]

[1]Clinical Professor of Surgery, University of Colorado School of Medicine, Aurora, CO
[2]Medical Program Director, Colorado Center for Health and Sports Science, Denver, CO
[3]Associate Professor of Pathology, Immunology and Laboratory Medicine, University of Florida College of Medicine, Gainesville, FL
[4]Assistant Professor of Surgery, Uniformed Services University of the Health Sciences, Bethesda, MD

[*]Corresponding Author:
Gerald M. Haase, University of Colorado School of Medicine, Aurora, Colorado, USA
E-mail: gerald.haase@cuanschutz.edu

Received: 01 Jan 2026
Accepted: 10 Jan 2026
Published: 12 Jan 2026
J Short Name: ACMCR

Keywords: Testosterone; Pine Pollen; Hypogonadism; Young Men; Low T

Citation: GM Haase. Pine Pollen Impacts Hypogonadal Symptoms in Younger Men with Variations in Androgen Levels: Pilot Observations. Anna Clin Med Case Rep®. 2026; 15(11): 1-8

1. Abstract

1.1. Purpose

This pilot is a partner trial to a previously published study of older men [1]. The primary goal was to assess the effects of consuming a proprietary tincture form of Pine Pollen extract (Pinus massoniana pollen) during an eight-week open-label trial on the clinical outcomes in younger men with initial symptoms of low testosterone. The secondary goal was to determine the total and free testosterone levels in the same cohort and determine if there was any correlation with symptomatology.

1.2. Methods

Men between the ages of 25 and 50 years were randomly recruited. Individuals with confounding factors or specific allergic, prostate or cardiometabolic histories that may cause undue risk in participation were prospectively excluded. The remaining 14 subjects were enrolled after appropriate informed consent was obtained and 11 men completed the trial. The study consisted of eight weeks of supplement consumption with Total Testosterone (TT), Steroid Hormone Binding Globulin (SHBG) and Free Testosterone (FT) blood measurements at pre-study baseline and at the end of the trial. At the same time points, completion of a hybrid 5-point scale survey derived from the qualitative Androgen Deficiency in the Aging Male (qADAM), Sexual Health Inventory for Men (SHIM) and International Index of Erectile Function (IIEF) questionnaires was obtained.

1.3. Results

Mean total scores on the hybrid symptom questionnaire increased from 28.36 to 39.55 with a highly statistically significant t-test value of P=0.000717. Mean scores for the Quality-Of-Life (QOL) portion of the survey increased from 13.09 to 19.45, significantly at P=0.000234 level. Mean scores for the sexual function survey portion also increased significantly from 15.27 to 20.09, P=0.00129. Initial TT levels varied widely between 204 and 838 ng/dL with a mean of 499.2 ng/dL. Final TT levels likewise varied widely between 190 and 1003 ng/dL with a mean of 488.4 ng/dL representing no significant change. Simultaneously, the mean SHBG levels decreased significantly from 29.1 to 27.4 nmol/L, P=0.0016. This resulted in a significant increase in mean FT levels from 10.48 to 11.72 ng/dL, P=0.0429.

1.4. Conclusions

The current pilot study demonstrated that a proprietary pine pollen tincture can positively affect lifestyle and sexual factors in this cohort of younger men within eight weeks. Since the baseline total testosterone levels varied widely and were generally high at onset, only half the subject's levels increased further. However, the decrease in SHBG resulted in significantly higher values for the critical FT levels and paralleled the improvements in symptoms. This uniquely constituted pine pollen supplement may be a promising option for symptomatic younger men regardless of androgenic hormone levels who prefer a natural supplement rather than direct testosterone replacement. These outcomes in symptom improvement correlate with previously published similar findings in older individuals and further confirm the potential benefits of pine pollen for a broad male population.

2. Introduction

Interest in testosterone deficiency and testing as well as boosting and replacement strategies have increased dramatically in recent years. This main male androgenic (sex) hormone is critical to the properly functioning of a broad spectrum of physiological processes. These relate to physical status, quality of life factors, cognitive changes and emotional function, the latter especially correlated to the hypothalamic interplay between testosterone and oxytocin [2,3]. In younger men, sexual issues, such as libido and erectile dysfunction, dominate the biological picture and clinical concerns of affected individuals [4,5]. Average male testosterone levels peak in the mid-20s and decline from that point, with the average decrease approximating two percent per year after age 30 [6]. While levels of TT below 300 ng/dL are usually considered to be in the low range, the direct linkage to clinically relevant symptomatology is complicated [7]. This may be because the majority of testosterone is not a molecule free to exert its biological effect but is bound to other proteins including SHBG. While FT is likely the best marker of a person's biological androgen status, the analysis requires complex equilibrium

dialysis methodology and is difficult to reproducibly measure. Thus, SHBG level with the related Free Androgen Index (FAI) may be considered a potential estimate of FT level, though not perfect and currently controversial [8, 9]. Nevertheless, when both testosterone and SHBG are simultaneously determined by the same immunoassay technique, as was performed in this study, a valid calculated FT level can be ascertained. The issue is of clinical consequence since a substantial portion of the apparent low libido, sexual dysfunction, decreased strength, and depressed mood is caused by lower circulating androgen levels [10,11].

Male hypogonadism may be associated with low TT/FT levels and its symptoms adversely impact men's physical health, sexual function, emotional status and overall well-being [4]. Therefore, strategies to elevate this critical hormone have become a common focus of current medical practice. Therapeutic options include direct hormone replacement via multiple routes of administration as well as consumption of agents that induce endogenous testosterone production to increase levels. Treatment rationale highlights the alleviation of negative symptoms and improvement in sexual health and quality of life while possibly elevating serum testosterone levels [12,13]. While validated survey tools can assess various selected aspects of health, each generally emphasizes only specific domains [14,15]. To obtain a more global viewpoint with regard to the success of therapeutic interventions, it appears rational to develop a hybrid questionnaire containing a broad spectrum of items derived from several survey instruments. This combination of questions may assist in proper clinical substantiation of any particular method of testosterone deficiency management. Ultimate success depends on the implementation of an approach that is employed for the proper diagnosis, in a personalized manner, with an accurate risk-benefit analysis and informed, patient-centered, decision making [16,17].

In light of the widespread interest in testosterone, several approaches to hormone elevation merit consideration. Natural lifestyle methods include intense exercise regimens, improving sleep patterns, ideal weight management and dietary manipulation. However, even if employed properly, these programs are inconsistent and of limited long-term effectiveness. Exogenous testosterone replacement is readily available in several modes of administration and is generally successful. In the past, theoretical concerns about chronic usage had been raised relative to cardiovascular disease and prostate cancer risk. Most recent studies have not demonstrated these concerns to be clinically significant [18-22]. Nevertheless, because of persisting safety and fertility preservation concerns, some non-testosterone-based treatments have been employed and proved efficacious [23]. In addition, a variety of vitamins, minerals, and phytonutrients have been purported to elevate testosterone levels and alleviate bothersome hypogonadism symptoms in males.

Pine pollen from multiple pine tree species is a natural plant-based product with a centuries-long history of common safe use in traditional Chinese medicine. In recent years, intense interest in emerging science has influenced Western holistic and complementary medical practices to employ this phytonutrient as an androgenic steroid-boosting supplement. One mechanism presumed responsible for clinical outcomes is the presence of dominant phytoandrogens as well as some phytoestrogens, both being plant-derived compounds exhibiting androgenic effect similar to testosterone [24,25]. Pine pollen also includes polysaccharides, vitamins, phospholipids, amino acids, minerals, enzymes, polyphenols, fiber, and proteins [26-29].

Most of the initial health-based benefits ascribed to pine pollen were demonstrated by observations in experimental in vitro laboratory systems or in vivo animal models. Nevertheless, the investigational findings were impressive and related to antiaging effects and antioxidant activity [30-33]. In addition, studies demonstrated potent immune-enhancing properties [34-36] as well as potentially beneficial impacts on intestinal disease, arthritis, and hepatic and colon cancer [37-43]. Because few human studies were available, we previously evaluated a proprietary pine pollen extract in a beta clinical experience in older men with symptoms of hypogonadism. This pilot trial demonstrated positive clinical effects confirming testosterone elevation and quality of life benefits [1]. Therefore, it seemed appropriate to assess the effects of the same pine pollen tincture in a cohort of younger males to confirm and expand the previous research findings to a broader population. Pine pollen was shown to be quite safe for oral consumption and the initial trial showed no adverse side effects. While it is possible to experience some initial mild stomach upset, this was not a complaint noted in the beta study. While allergic responses may occur, severe reactions are rare and generally limited to individuals with known allergic histories [44].

3. Materials and Methods

The study was approved by the Institutional Review Board of the Colorado Center for Health and Sports Science and each subject signed an appropriate Informed Consent document. Participants were prospectively and randomly recruited from a male population between the ages of 25 to 50 years who perceived they had health issues possibly related to low testosterone levels. They were instructed to review the common quality of life and sexual symptoms associated with low testosterone to enhance appropriate study subject matching. To qualify, subjects had to determine that they had at least three of the listed symptoms, that included low libido in terms of sexual interest and erectile function, low life enjoyment, poor energy and increased fatigue, as well as mood and emotional dysfunction. These descriptors were derived from a combination of metrics from three validated instruments including the qADAM survey, the SHIM inventory and the IIEF questionnaire for the initial screen [14,45,46]. In addition, a participant could not have a personal or family history for prostate cancer or other significant medical disease. Nine potential subjects were removed due to having positive study exclusion criteria.

Subjects disclosed all current medications and supplements for clinical and safety review. They also listed their exercise and lifestyle routines for additional review. Participation required that lifestyle, nutrition, supplements and medications remain consistent over the eight-week trial period. If a subject was taking biotin, he was instructed to stop that supplement three days before blood sampling to ensure there was no conflict with the blood test analysis.

The initial study group included 14 males, but two subjects were removed from the study shortly after onset due to non-

compliance with testing, survey or supplement consumption instructions. One further participant developed a non-related illness that precluded his completion of the trial. For the remaining evaluable subjects (n=11), the mean age was 40.15 years.

The supplement used for the study was Pinus massoniana pollen (Lost Empire Herbs, Kansas City, MO). This proprietary formulation has been quantitatively analyzed to contain high concentrations of the androgenic steroidal phytohormones, brassinosteroids and gibberellins, that are beneficial to growth and hormone balance. The compound is sterilized by flash steaming technique, and the pine pollen is concentrated utilizing hydroethanolic extraction. Employing 50% organic cane alcohol and 50% deionized water for this step provides a 50% alcohol by volume ratio. This methodology results in each finished bottle of supplement containing approximately 18 grams of pine pollen extract. This produces a 300 mg per 1mL dose in a tincture solution for oral delivery and absorption under the tongue. The total recommended daily dose of 1mL, was achieved in the study as ½ of a dropper full in the morning and the same volume consumed in the evening as shown in Figure 1. Participants consumed the supplement twice per day for five consecutive days and then took a two-day break. The identical cycle of the five-days on and two-days off regimen was repeated for the duration of the trial period.

At baseline and after eight weeks, the participants completed the hybrid-constructed questionnaire, derived from the qADAM, SHIM and IIEF surveys. This hybrid survey expands the response possibilities to include a 5-point Likert-type rating scale, assessing each question from one to five (47). Each subject completed the entire ten-question panel, divided equally between questions related to QOL factors and those associated with sexual function (Table 1). The questionnaire was administered electronically on the same day as the subject blood test samples were collected. For each survey, the subjects were asked to recall their experience and feelings and thus generate a rating for the seven days prior to the survey.

Health care professionals may opt to use validated scales and similar metrics, alone or in conjunction with testosterone blood levels in screening for hypogonadism although some published guidelines may not support this approach [7]. As

Figure 1: Lost Empire Herbs Pine Pollen Tincture.

Table 1: Ten-Question Pine Pollen Hybrid Survey

Quality of Life Section
1. How would you rate your overall energy?
2. How would you rate your strength/endurance?
3. How would you rate your enjoyment of life?
4. How would you rate your happiness level?
5. How would you rate your activity/sports ability over the past week?
Sexual Function Section
1. Rate your confidence in achieving and maintaining an erection.
2. After sexual stimulation, how often is your erection hard enough for penetration of your partner?
3. During sexual intercourse, how often can you maintain an adequate erection after penetration of your partner?
4. During sexual intercourse, how difficult is it to maintain your erection to the completion of intercourse?
5. How often is sexual intercourse satisfactory for you?

the survey evaluates various lifestyle and sexual factors, it can chart dysfunction and improvement in measures critical to a specific individual. For the QOL section, the number "1" was denoted as "terrible," and equated to a rating of “very dissatisfied”, while the number "5" was denoted as “excellent” and equated to a rating of "very satisfied." Thus, the tabulated questions had a potentially low score of five and a potentially high score of 25. As the “average” rating in each item was three, 15 points indicated that the subjects considered themselves as average. When the scores were totaled for all questions, a lower aggregate score generally parallels higher dysfunction than average relative to androgenic hormone domains. Conversely, higher scores above 15 generally correlate with milder dysfunction and possibly more robust androgen levels. A similar rating scale was used for the sexual function section except that these questions generally rated “frequency” or “difficulty” on the “1” to “5” scale. The potential scores again ranged from five to 25 for this section and the total composite score ranged from ten to 50.

For TT and SHBG level analyses, subjects utilized an at-home sample collection test kit (LetsGetChecked-LGC, Monrovia, California). This system has been shown to provide clinically reliable diagnostic test results from self-collected blood sample kits as depicted in Figure 2. LGC is state-licensed and certified through the federal Clinical Laboratory Improvement Amendments (CLIA) program administered by the Centers for Medicare & Medicaid Services, the agency that regulates all laboratory testing performed on individuals in the U.S. LGC is further accredited by the College of American Pathologists (CAP) program that inspects human testing facilities and ensures their compliance with the highest standards in laboratory medicine and technology. The statistical significance difference of all metrics was determined by employing the Student’s t-test.

The methodology utilized in this study was the U.S. Food and Drug Administration approved Elecsys® Testosterone II assay and the Elecsys® SHBG assay (Roche Pharmaceuticals). These tests are an immunoassay for the in vitro quantitative analysis of testosterone and SHBG levels

in human serum and plasma [48]. Using patented technology, this electrochemiluminescence technique is employed on the Cobas e 801 immunoassay analyzer, a high throughput module (49). The method is based on a competitive test principle using a high-affinity sheep monoclonal antibody directed explicitly against testosterone and two monoclonal antibodies specifically directed against SHBG. This laboratory was selected due to validated accuracy, CLIA/CAP certification and the ease of collecting very early morning samples when testosterone levels are the highest.

Although thought by some to be inconsistent, the FAI is one method to determine an approximation of androgen status [8,9]. Its accuracy increases if both testosterone and SHBG are similarly immunoassayed, and the units of the former are converted from ng/dL to nmol/L to match the latter. The testosterone conversion factor is 0.0347 ng/dL per nmol/L. The resulting TT value is divided by the SHBG level and then multiplied by the constant 100. Since both serum concentrations are expressed in nmol/L, the FAI has no unit designation. However, because the index may not always be indicative of true FT level, it was not employed in this analysis. Nevertheless, as previously noted, the FT value can be obtained by calculation from TT and SHBG as determined by immunoassay and provides a metric to reliably detect the critical bioavailable androgen levels [50].

4. Results

Of the 14 initial subjects, 11 completed the entire eight weeks of product consumption and all testing/assessments. The initial raw scores for the QOL questions ranged from 9 to 19 (mean 13.09) and only three of the participants considered themselves "above average" (above 15) at baseline. The final raw scores for this section ranged from 9 to 24 (mean 19.45, P=0.000234) and all but one subject considered themselves "above average" at study completion. The sexual function section demonstrated a similar pattern. The initial raw scores for this section ranged from 8 to 19 (mean 15.27) and the final raw scores ranged from 8 to 25 (mean 20.09, P=0.00129). The number of subjects who considered themselves "above average" (above 15) increased from six to ten at study completion. The mean composite outcome level for the survey increased from 28.36 to 39.55 and was highly statistically significant with a t-test value of P=0.000717 (Figure 3).. All subjects reported at least stable or improving scores for each survey question at the end of the trial. The individual changes are listed in Table 2.

The initial TT levels ranged from 229 to 838 ng/dL (mean 499.2 ng/dL) at baseline and the final TT levels ranged from 190 to 1003 ng/dL (mean 488.4 ng/dL). The levels increased in five subjects, decreased in five and were essentially unchanged in one participant. There was no significant difference between the baseline and end of study values (P=0.7663). The initial SHBG levels ranged from 9.28 to 61.4 nmol/L (mean 29.1 nmol/L) at baseline. The final SHBG levels ranged from 8.59 to 58.8 nmol/L (mean 27.4 nmol/L) demonstrating a statistically significant six percent decrease (P=0.0016). The mean aggregate SHBG level decreased by 1.7 nmol/L and is graphically depicted in Figure 4. The initial FT levels ranged from 4.4 to 14.8 ng/dL (mean 10.48 ng/dL) at baseline and the final FT levels ranged from 7.7 to 16.6 ng/dL (mean 11.72 ng/dL). The average improvement in FT was approximately 12 % for the entire study cohort and was statistically significant (P=0.0427). The FT levels ranged from 1.66% to 3.38% as a percentage of TT, falling within the expected clinical ranges for unbound androgens. The individual testosterone results are listed in Table 3.

5. Discussion

This prospective beta observational trial is one of few studies to describe the impact of a unique pine pollen extract on serum androgen levels and related clinical symptoms in younger men. This study expanded the beneficial life quality findings from our previous older men study, but also revealed differences related to testosterone levels in this younger male cohort. These observations hold clinical relevance since the positive effects are demonstrated in a broad age population and provide some reasonable generalizability to the results.

Figure 2: Blood Test Kit Example, LetsGetChecked.

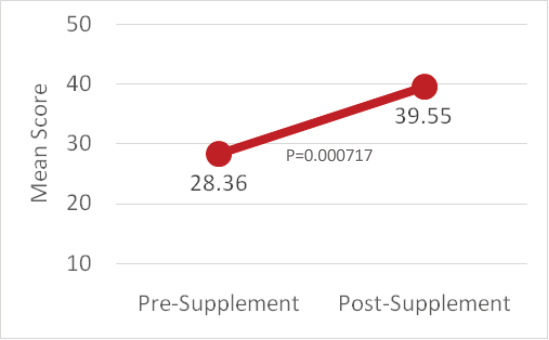

Figure 3: Mean Change in Composite Survey Scores

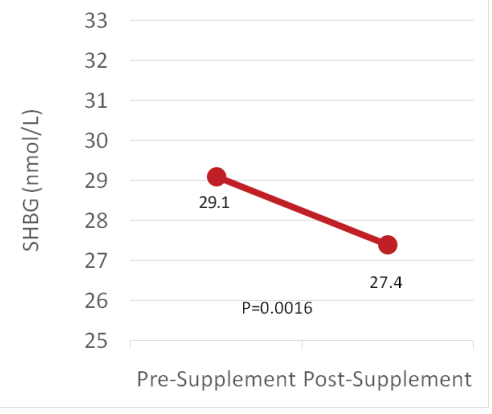

Figure 4: Mean Change in Steroid Hormone Binding Globulin

Table 2: Pre- and Post-Supplement Survey Scores by Subject.

Subject Number	Pre-Suppl QOL Section	Post-Suppl QOL Section	Pre-Suppl Sexual Funct	Post-Suppl Sexual Funct
1	19	22	15	16
2	11	20	17	19
3	17	24	19	25
4	16	18	17	23
5	9	9	8	8
6	14	20	14	16
7	12	21	17	25
8	9	21	18	25
9	13	19	14	22
10	13	22	13	24
11	11	18	16	18
Mean Score	13.09	19.45	15.27	20.09
T-test		P=0.000234		P=0.00129

Table 3: Pre- and Post-Supplementation Total and Free Testosterone Levels by Subject.

Subject Number	Pre-Suppl Total T (ng/dL)	Post-Suppl Total T (ng/dL)	Pre-Suppl Free T (ng/dL)	Post-Suppl Free T (ng/dL)
1	390	352	13.1	11.9
2	635	640	12.6	14.7
3	723	564	13.8	14.95
4	528	284	11.98	9.6
5	355	356	8.06	11.69
6	204	335	4.4	7.7
7	618	574	10.26	12.2
8	369	454	11.1	12.2
9	603	620	10	11.4
10	838	1003	14.8	16.6
11	229	190	5.2	5.9
Mean Value	499.2	488.4	10.48	11.72
T-test		P=0.7663		P=0.0427

In addition, while extensive historical information exists in traditional Eastern medicine, empiric human data in Western allopathic medicine is scarce. While this investigation is a limited eight-week pilot, the outcomes demonstrated strong clinical improvement reasonably associated with FT levels although not necessarily related to TT values.

Concerns about exogenous testosterone consumption have led to the search for alternative strategies that more indirectly elevate androgen levels. A substantial number of individuals may be wary of pharmaceutical drug intervention and, thus, are attracted to natural supplement alternatives. Health benefits from pine pollen have been experienced and described in Chinese medicine for centuries. However, since the extract may be derived by various techniques). from different pine tree species, its composition, stability and bioavailability are not easily determined [51]. Therefore, this trial utilized a proprietary pine pollen extract in tincture form (Lost Empire Herbs) that was formulated by a unique extraction method to provide quality, consistency, efficacy and safety.

Total testosterone determination is the usual initial screening test in males who present with symptoms typical of low androgenic hormone levels. However, baseline serum testosterone levels may vary due to individual genetics, lifestyle differences and other factors [52,53]. Because most of the hormone is not in a free state to exert influence on tissues and organs, simultaneous measurement of SHBG may assist in determining the actual free testosterone levels. In this study, the initial androgen value range was exceptionally wide varying from 204 to 838 ng/dL. Therefore, health care professionals often consider symptoms rather than only androgen levels in guiding possible treatment and measuring therapeutic success [10,11,13]. In fact, TT blood levels in the current investigation did not significantly change on average for the entire cohort (499.2 to 488.4 ng/dL). Only about half the participants increased their TT levels from the beginning to the end of the trial, likely related to the high initial values and the extremely wide baseline level range. This finding contrasts with the previous study in older men who showed a lower and narrower baseline TT level range of 209 to 563 ng/dL and achieved androgen improvement by supplementation [1]. However, as expected, SHBG levels uniformly decreased, and the significant six percent mean reduction resulted in less of the available androgen being bound. Therefore, a concomitant significant increase in mean FT levels could be achieved (10.48 to 11.72 ng/dL, P=0.0427). All blood samples were analyzed by the same CLIA/CAP certified laboratory and supervised by an academic pathologist, thereby producing acceptable ranges for the results and reducing confounding variances. This has relevance considering the observed differences for androgen parameters between younger and older men. These outcomes help confirm the validity of the current study observation that despite varying TT result levels, clinical symptoms and FT levels uniformly and significantly responded positively to pine pollen supplementation.

The beneficial outcomes related to symptoms in younger men parallels the experience in older men and defines a strength of this study. Development of a relevant hybrid questionnaire instrument, derived from three validated symptom scales was also a particularly robust characteristic of the current trial. The surveys effectively assessed the changes in clinical symptoms of sexual function and quality of life factors over time so the participants could also personally appreciate the benefits from the tincture. After eight weeks of supplementation, exit interviews with the subjects revealed that the improvements were readily noticeable by themselves as well as by their available spouses/partners. Ten of the 11 evaluable participants reported positive benefits across the scales of the ten combined items queried. One subject reported no changes. The mean score for the group was 28.36 points initially and increased to 39.55 points by the end of eight weeks, a highly statistically significant t-test change at the P-0.000717 level. It was further observed that no participants experienced any allergic reactions or other adverse side effects to the pine pollen.

This younger men's pilot investigation parallels the clinical symptom benefits from the previous trial in older men although the testosterone outcomes were not uniform. Therefore, it still appears rational to consider consuming unique selected natural products to address androgen levels and improve related hypogonadal symptoms. This trial seems to confirm the observations of many practicing urologists that the TT blood level, especially in younger men, may not always track with the individual's clinical findings, while the FT levels may be more predictive. The study is limited by the open label design, the limited number of subjects and the wide variability and generally high baseline TT measurements. However, the participants were personally monitored to minimize recall bias, and the proper tincture consumption was carefully and frequently confirmed. Subsequent trials with larger subject numbers may provide greater insight into the relationship between androgen status and symptoms of men in all stages of life. In addition, home-based blood sampling with remote laboratory analysis as achieved in this pilot simplifies individual patient utilization and monitoring for both clinical and research purposes.

6. Conclusion

An orally consumed proprietary pine pollen extract had a variable effect on TT and a significant beneficial effect on FT levels in younger men over an eight-week prospective clinical trial. In addition, the unique supplement significantly improved a broad spectrum of personally relevant hypogonadal symptoms during the same time-period. The extract in tincture form was easily tolerated and did not cause any adverse side effects.

References

1. Wolkodoff NE, Haase GM, Mordkin RM, Beal SG. Pine pollen impacts testosterone-related symptoms in older men: a pilot report. Ann Clin Med Case Rep. 2024;14(5):1-8.
2. Crespi BJ. Oxytocin, testosterone, and human social cognition. Biol Rev Camb Philos Soc. 2016;91(2):390-408.
3. Quintana DS, Glaser BD, Kang H, Kildal ESM, Audunsdottir K, Sartorius AM, et al. The interplay of oxytocin and sex hormones. Neurosci Biobehav Rev. 2024;163:105765.
4. Morales A. Androgens are fundamental in the maintenance of male sexual health. Curr Urol Rep. 2011;12(6):453-60.
5. Corona G, Rastelli G, Isidori AM, Pivonello R, Bettocchi C, Reisman Y, et al. Erectile dysfunction and cardiovascular risk: a review of current findings. Expert Rev Cardiovasc Ther. 2020;18(3):155-64.
6. Cohen J, Nassau DE, Patel P, Ramasamy R. Low testosterone in adolescents & young adults. Front Endocrinol (Lausanne). 2020;10:916.
7. Mulhall JP, Trost LW, Brannigan RE, Kurtz EG, Redmon JB, Chiles KA, et al. Evaluation and management of testosterone deficiency: AUA guideline. J Urol. 2018;200:423-32.
8. Rosner W, Auchus RJ, Azziz R, Sluss PM, Raff H. Position statement: Utility, limitations, and pitfalls in measuring testosterone: an Endocrine Society position statement. J Clin Endocrinol Metab. 2006;92(2):405-13.
9. Kapoor P, Luttrell B, Williams D. The free androgen index is not valid for adult males. J Ster Biochem Mol Biol.1993;45(4):325-6.
10. Khera M, Adaikin G, Buvat J, Carrier S, El-Meliegy A, Hatzimouratidis K, et al. Diagnosis and treatment of testosterone deficiency: recommendations from the Fourth International Consultation For Sexual Medicine (ICSM 2015). J Sex Med. 2016;13(12):1787-804.
11. Morgenthaler A, Traish A, Hackett G, Jones TH, Ramasamy R. Diagnosis and treatment of testosterone deficiency: updated recommendations from the Lisbon 2018 international consultation for sexual medicine. Sex Med Rev. 2019;7(4):636-49.
12. Bhasin S, Storer TW, Berman N, Yarasheski KE, Clevenger B, Phillips J, et al. Testosterone replacement increases fat-free mass and muscle size in hypogonadal men. J Clin Endocrinol Metab. 1997;82(2):407-13.
13. Bhasin S, Brito JP, Cunningham GR, Hayes FJ, Hodis HN, Matsumoto AM, et al. Testosterone therapy in men with hypogonadism: an endocrine society clinical practice guideline. J Clin Endocrinol Metab. 2018;103(5):1715-44.
14. Mohamed O, Freundlich RE, Dakik HK, Grober ED, Najari B, Lipshultz LI, et al. The quantitative ADAM questionnaire: a new tool in quantifying the severity of hypogonadism. Int J Impot Res. 2010;22(1):20-4.
15. Bernie AM, Scovell JM, Ramasamy R. Comparison of questionnaires used for screening and symptom identification in hypogonadal men. Aging Male. 2014;17(4):195-8.
16. Brawer MK. Testosterone replacement in men with andropause: an overview. Rev Urol. 2004;6(Suppl 6):S9-S15.
17. Corona G, Otavio Torres L, Maggi M. Testosterone therapy: what have we learned from trials. J Sex Med. 2020;17(3):447-60.
18. Bhasin S, Travison TG, Pencina KM, O'Leary M, Cunningham GR, Lincoff AM et al. Prostate safety events during testosterone replacement therapy in men with hypogonadism: a randomized clinical trial. JAMA Netw Open. 2023;6(12):e2348692.
19. Xu Z, Chen X, Zhou H, Ren C, Wang Q, Pan Y, et al. An updated systematic review and meta-analysis of the effects

of testosterone replacement therapy on erectile function and prostate. Front Endocrinol (Lausanne).2004;15:1335146.

20. Corona G, Rastelli G, Guaraldi F, Tortorici G, Reismann Y, Sforza A, et al. An update on heart disease risk associated with testosterone boosting medications. Expert Opin Drug Saf. 2019;18(4):321-32.
21. Lincoff AM, Bhasin S, Flevaris P, Mitchell LM, Basaria S, Boden WE, et al. Cardiovascular safety of testosterone-replacement therapy. N Engl J Med. 2023;389(2):107-17.
22. Trost L. Update to the testosterone guideline. J Urol. 2024;211:608-10.
23. Raheem OA, Chen T, Prasad Akula K, Greenberg J, Le TV, Chernobylsky D, et al. Efficacy of non-testosterone-based treatment in hypogonadal men: a review. Sex Med Rev. 2021;9(3):381-92.
24. Saden-Krehula M, Tajic M, Kolbah D. Testosterone, epitestosterone and androstenedione in the pollen of Scotch pine P. silvestris L. Experientia. 1971;27(1):108-9.
25. Kopylov AT, Malsagova KA, Stepanov AA, Kaysheva AL, et al. Diversity of plant sterols metabolism: the impact on human health, sport, and accumulation of contaminating sterols. Nutrients. 2021;13(5):1623.
26. He XY, Sun XY, Yu ZY, Lai BY, Zhang YP, Cao HJ. Effective components and pharmacological function of pine pollen. J Northeast For University. 2007;35(9):78-80.
27. Mao YQ: Review of nutrient composition and health care function of pine pollen. Chin Food Nutr. 2008;3:50-2.
28. Liang S-B, Liang N, Bu FL, Lai BY, Zhang YP, Cao HJ, et al. The potential effects and use of Chinese herbal medicine pine pollen (Pinus pollen): a bibliometric analysis of pharmacological and clinical studies. World J Tradit Chin Med. 2020;6(2):163-70.
29. Strohl MJ, Seikel MK. Polyphenols of pine pollens: A survey. Phytochemistry. 1965;4(3):383-99.
30. Lee KH, Kim AJ, Choi EM. Antioxidant and anti-inflammatory activity of pine pollen extract in vitro. Phytother. Res. 2009;23:41-8.
31. Mao GX, Zheng LD, Cao YB, Chen ZM, Lv YD, Wang YZ, et al. Antiaging effect of pine pollen in human diploid fibroblasts and in a mouse model induced by D-galactose. Oxid Med Cell Longev. 2012;2012:750963.
32. Zhou C, Yin S, Yu Z, Feng Y, Wei K, Ma W, et al. Preliminary characterization, antioxidant and hepatoprotective activities of polysaccharides from Taishan Pinus Massoniana Pollen. Molecules. 2018;23(2):281.
33. Keriene I, Sauliene I, Sukiene, L, Judžentienė A, Ligor M, Buszewski B. Patterns of phenolic compounds in Betula and Pinus pollen. Plants (Basel). 2023;12(2):356.
34. Kobayashi N, Unten S, Kakuta H, Komatsu N, Fujimaki M, Satoh K, et al. Diverse biological activities of healthy foods. In Vivo. 2001;15(1):17-23.
35. Wei K, Sun ZH, Tan XL, Wang H, Wang XJ, Zhu R. Study on the immune enhancement effect of Taishan pine pollen polysaccharide on mice. China Agric Sci. 2010;43:3645-52.
36. Yang S, Wei K, Jia F, Zhao X, Cui G, Guo F, et al. Characterization and biological activity of Taishan Pinus massoniana pollen polysaccharide in vitro. PLoS One. 2015;10(3):e0115638.
37. Zhou LG, Windisch WM, Roth FX, Eder K, Ettle T, et al. Nutritive value of Masson pine pollen (Pinus massoniana) in comparison to wheat bran and effects on stool characteristics in a pig model. Agriculture and Food Sciences. 2007. Corpus ID: 44009252
38. Li Z, Wang H, Wang Z,Geng Y. Pine pollen polysaccharides' and sulfated polysaccharides' effects on UC mice through modulation of cell tight junctions and RIPK3-dependent necroptosis pathways. Molecules.2022;27(22):7682.
39. Lee KH, Choi EM. Effect of pine pollen extract on experimental chronic arthritis. Phytother Res. 2009;23(5):651-7.
40. Chu HL, Mao H, Feng W, Liu JW, Geng Y. Effects of sulfated polysaccharide from Masson pine (Pinus massoniana) pollen on the proliferation and cell cycle of HepG2 cells. Intl J Biol Macromol. 2013;55:104-8.
41. Jin X, Cong T, Zhao L,Ma L, Li R, Zhao P, et al. The protective effects of Masson pine pollen aqueous extract on CCI4-induced oxidative damage of human hepatic cells. Int J Clin Exp Med. 2015;8(10):17773-80.
42. Su F, Sun M, Geng Y. H-NMR metabolomics analysis of the effects of sulfated polysaccharides from Masson pine pollen in RAW267.7 macrophage cells. Molecules. 2019;24(9):1841.
43. Shang H, Niu X, Cui W, Sha Z, Wang C, Huang T, et al. Anti-tumor activity of polysaccharides extracted from Pinus massoniana pollen in colorectal cancer-in vitro and in vivo studies. Food Funct. 2022;13(11):6350-61.
44. Kim M, Ahn Y, Yoo Y, Kim DK, Yang HJ, Park HS, et al: Clinical manifestations and risk factors of anaphylaxis in pollen-food allergy syndrome. Yonsei Med J. 2019;60(10):960-8.
45. Rosen R, Riley A, Wagner G, Osterloh IH, Kirkpatrick J, Mishra A: The international index of erectile function (IIEF): a multidimensional scale for assessment of erectile dysfunction. Urology 1997;49(6):822-30.
46. Rosen RC, Cappelleri JC, Smith MD,Lipsky J, B M Peña Development and evaluation of an abridged 5-item version of the international index of erectile function (IIEF-5) as a diagnostic tool for erectile dysfunction. Int J Impot Res. 1999;11:319-26.
47. Sullivan GM, Artino Jr AR. Analyzing and interpreting data from Likert-type scales. J Grad Med Educ. 2013;5(4):541-2.
48. Owen WE, Rawlins ML, Roberts WL. Selected performance characteristics of the Roche Elecsys® testosterone II assay on the Modular analytics E 170 analyzer. ClinicaChimica Acta. 2010;411(15-16):1073-9.
49. Nörz D, Olearo F, Perisic S, Bauer MF, Riester E, Schneider T, et al. Multicenter evaluation of a fully automated high-throughput SARS-CoV-2 antigen immunoassay. Infect Dis Ther. 2021;10(4):2371-9.
50. Vermeulen A, Verdonck L, Kaufman JM. A critical evaluation of simple methods for estimation of free testosterone in serum. J Clin Endocrinol Metab. 1999;84(10): 3666-72.
51. Cheng Y, Wang Z, Quan W, Xue C, Qu T, Wang T, et al. Pine pollen: a review of its chemical composition, health effects, processing, and food applications. Trends Food Sci Technol. 2023;138:599-614.

52. Ramasamy R, Golan R, Wilken N, Scovell JM, Lipshultz LI. Association of free testosterone with hypogonadal symptoms in men with near-normal total testosterone levels. Urology. 2015;86(2):287-90.

53. Dhindsa SS, Irwig MS, Wyne K. Gonadopenia and aging in men. Endo Pract. 2018;24(4):375-85.