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REVIEW PAPER

Physical activity as a modifiable factor supporting mental well-being in men with symptoms of age-related androgen decline: a narrative literature review

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Abstract

Male ageing is associated with biological, psychological, and social changes, including symptoms linked to age-related androgen decline, such as reduced energy, low mood, sleep disturbances, decreased libido, lower self-esteem, and impaired quality of life. This narrative literature review aims to discuss physical activity as a modifiable factor that may support the psychological well-being of men experiencing symptoms associated with age-related androgen decline, particularly mood, depressive symptoms, quality of life, self-esteem, and psychosocial functioning. The review draws on scientific publications from 2023-2026 available in PubMed, Scopus, Web of Science, PsycINFO, and SPORTDiscus, supplemented by references from selected reviews, meta-analyses, and clinical guidelines addressing physical activity, men's mental health, late-onset hypogonadism, testosterone deficiency, and age-related androgen changes. Available evidence suggests that physical activity may contribute to comprehensive mental health support in ageing men but does not replace the diagnosis and treatment of clinically confirmed hypogonadism. Potential biopsychosocial mechanisms include improvements in physical fitness, body composition, metabolic function, and sleep quality, as well as increased self-efficacy, self-esteem, and social support. These processes should not be interpreted solely in terms of changes in testosterone levels, and their role as mediators of improved psychological well-being requires further investigation.

Keywords: late-onset hypogonadism, hypogonadism, men's health, mental health, exercise

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Introduction

Male ageing is a multidimensional process involving biological, psychological, and social changes that can affect quality of life. This phenomenon may be clinically significant for some men, particularly when hormonal changes are accompanied by somatic, sexual, and psychological symptoms [1,2]. In literature, this set of age-related changes has sometimes been described as "andropause", though this term requires cautious use. In the present paper, "andropause" is treated as a descriptive term, whereas more precise designations – such as age-related androgen decline, testosterone deficiency, and late-onset hypogonadism (LOH) – are preferred for scientific analysis.

The concept of "age-related androgen decline" refers to the age-associated reduction in androgen levels and is primarily descriptive in nature; it does not automatically indicate a disease or imply the need for treatment. The term "testosterone deficiency" refers to a

laboratory-confirmed lack of testosterone that should be interpreted in the context of the patient's clinical symptoms and overall health. LOH, on the other hand, refers to a clinical condition in which low testosterone levels are accompanied by significant somatic, sexual, or psychological symptoms. Current guidelines emphasize that the diagnosis of hypogonadism in men should be based on a simultaneous assessment of clinical symptoms and consistently low testosterone levels, rather than solely on age or nonspecific complaints [3-5]. The significance of age-related androgen changes for men's mental well-being remains a complex issue. Hypogonadism and symptoms attributed to testosterone deficiency may coexist with low mood, depressive symptoms, anxiety, fatigue, sleep disturbances, reduced self-esteem, and impaired quality of life. However, available data do not allow these symptoms to be attributed solely to low testosterone levels, as a similar clinical picture can result from chronic diseases, metabolic disorders, abnormal body weight, low physical activity, chronic stress, and psychosocial factors [1,2]. Therefore, symptoms associated with the age-related decline in androgens should be analyzed within a broader biopsychosocial framework. In this context, physical activity represents a significant, modifiable lifestyle factor that can support the mental and functional health of middle-aged and older men.

Findings from recent systematic reviews and meta-analyses indicate that physical activity can reduce the severity of depressive symptoms, anxiety, and distress, while also supporting quality of life and mental well-being [6-8]. The mechanisms underlying this effect are multifactorial, involving biological, psychological, and social factors. Regular physical activity can improve physical fitness, sleep, and self-esteem, as well as enhance a sense of agency and support social participation [9]. Findings concerning men among whom physical activity may be associated with less severe depressive symptoms and better psychological functioning are of particular relevance to the present topic.

Studies indicate a relationship between physical activity and depressive symptoms in men, justifying the need for further analysis of this issue within the population experiencing symptoms associated with the age-related decline in androgens [10]. However, it should be emphasized that the benefits of physical activity should not be interpreted solely in terms of its potential effects on testosterone levels.

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Aim of the work

The aim of this literature review is to discuss the role of physical activity as a modifiable factor supporting the mental well-being of men experiencing symptoms associated with the age-related decline in androgens. Particular attention is paid to the relationships between physical activity and mood, depressive symptoms, quality of life, self-esteem, and psychosocial functioning. This approach allows for the integration of psychological and public health perspectives while maintaining the interpretive caution appropriate for a narrative literature review.

Methods

This work is a structured narrative review. The analysis focused on the relationships between physical activity and selected aspects of mental well-being, such as mood, depressive symptoms, quality of life, self-esteem, and psychosocial functioning.

The literature review was conducted based on scientific publications from the 2023-2026 period available in the PubMed, Scopus, Web of Science, PsycINFO, and SPORTDiscus databases, as well as through an analysis of the reference lists of selected review articles, meta-analyses, and clinical guidelines. Selected publications outside the specified time frame were also included, particularly the key World Health Organization (WHO) and American College of Sports Medicine (ACSM) guidelines and expert documents that provided a basis for interpreting recommendations regarding the type, intensity, frequency, and duration of physical activity.

The process of identifying, selecting, and including publications is illustrated by a simplified flow diagram inspired by the PRISMA 2020 guidelines (Figure 1). Given the narrative nature of the review, the diagram was used to structure the literature selection process. A total of 37 publications relevant to the scope of the review were included in the narrative synthesis. Publications unrelated to the topic and works of a purely journalistic nature were excluded. The analyzed sources were grouped into several thematic areas: terminology and diagnostics regarding LOH and testosterone deficiency; the association between hypogonadism and mental health; physical activity and depressive symptoms; physical activity, quality of life, and psychosocial functioning; physical activity in men; and the potential biological, psychological, and social mechanisms linking physical activity to mental well-being. Particular

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attention was paid to distinguishing the concept of "andropause" – as a descriptive term – from more precise clinical concepts such as age-related androgen decline, testosterone deficiency, and LOH.

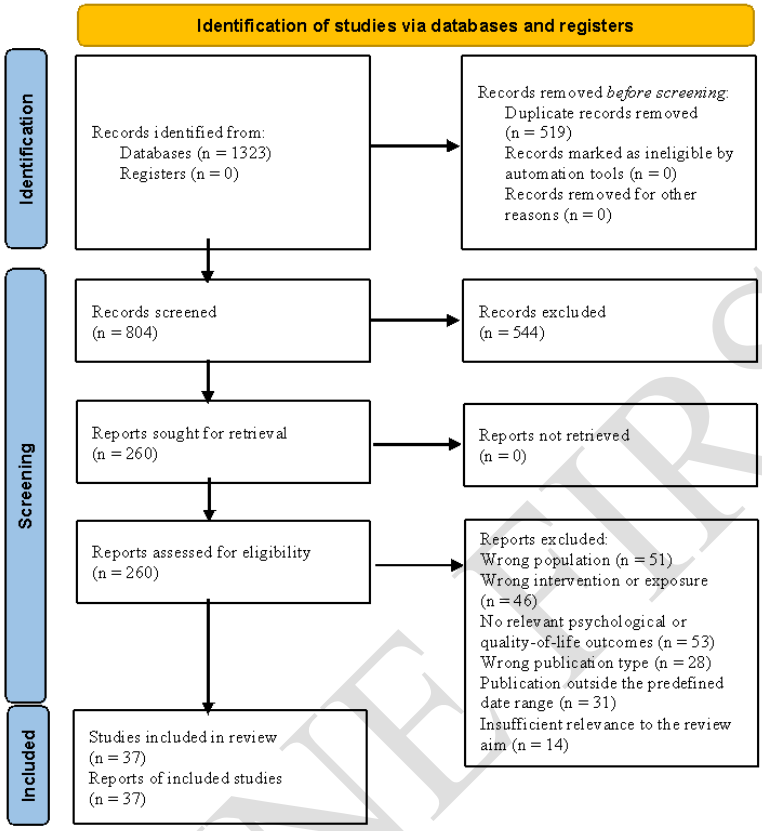


Figure 1. Simplified publication flow diagram inspired by the PRISMA 2020 guidelines
Notes: The diagram illustrates the process of identification, selection, full-text assessment, and inclusion of publications in the narrative synthesis and is intended solely for illustrative purposes.

Literature review results

Age-related androgenic changes and men's mental well-being

Age-related androgenic changes in men are typically gradual and do not constitute a distinct biological stage. With advancing age, men exhibit declining testosterone levels and alterations in hypothalamic-pituitary-testicular axis function. These changes are influenced by the presence of clinical symptoms, chronic diseases, body mass, metabolic status, physical activity levels, and overall health [3,5].

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It is essential to distinguish between the physiological, age-related decline in testosterone levels and clinically significant hypogonadism [4,5]. Symptoms associated with testosterone deficiency or hypogonadism may manifest across somatic, sexual, and psychological domains (e.g. chronic fatigue, reduced energy levels, decreased muscle mass and strength, increased body fat, impaired sleep quality, reduced overall physical performance, and decreased libido) [2,5].

The psychological and psychosocial aspects of age-related androgenic changes are of particular importance to this review. Symptoms attributed to testosterone deficiency may co-occur with low mood, reduced motivation, mental fatigue, lowered self-esteem, and a decline in quality of life, while hypogonadism may be associated with depressive symptoms, sleep disturbances, and impaired mental functioning [1,2]. The mental well-being of men experiencing these symptoms is shaped by biological, psychological, and social factors. The relationship between hypogonadism and depression is complex and should not be interpreted as a simple causal relationship. The association between androgen deficiency and depressive symptoms may be bidirectional and influenced by numerous confounding factors [1,11].

Symptom severity may reflect both potential androgen-related disorders and co-occurring psychological, social, occupational, or health-related problems [1,2,4,11].

Physical activity: mental well-being and quality of life

Physical activity can support mental health and overall well-being. Research indicates that higher levels of daily activity and participation in structured exercise programs may be associated with better mental functioning [7,9,12]. At the same time, there is no single, universally optimal type of activity for all patients. The effectiveness of a program may depend on participant preferences, fitness levels, the presence of comorbidities, exercise intensity, and the ability to maintain a regular routine. Physical activity can serve as a supportive measure in managing depressive symptoms but should not be presented as a standalone substitute for specialized treatment [6-8,13,14]. Physical activity may contribute to reductions in distress and perceived stress. The association between physical activity and sleep quality may be one of the mechanisms mediating the relationship between physical activity and mental well-being. Regular activity can help regulate circadian rhythms and reduce psychophysical tension [7,9,15].

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In the case of group activities, social support and a sense of belonging may play an additional role. This relationship is likely bidirectional: participation in exercise programs can increase social interaction, while greater support and the presence of a partner or group can facilitate consistent engagement in physical activity [7,9,16].

Literature indicates that the effects of physical activity depend not only on its amount but also on voluntariness, opportunities for recovery, the level of control, and the social and environmental context of the activity.

Physical activity may represent an important protective and supportive factor for men's mental health [10,12]. However, research findings suggest that while physical activity can foster well-being, depressive symptoms may lead to a sedentary lifestyle and reduced social contact. Factors such as chronic illness, obesity, socioeconomic status, and occupational stress may also play a significant role. Consequently, the relationship between physical activity and depressive symptoms in men should be viewed as part of a broader biopsychosocial model rather than as an isolated biological mechanism [10,12].

Research findings suggest that psychological benefits may also occur at levels of physical activity below those required to fully meet exercise recommendations. However, this does not imply the existence of a single, universal "dose" of activity suitable for everyone. The relationship between the dose of physical activity and mental health is influenced by factors such as intensity, frequency, duration, baseline activity levels, and health status. Overly demanding or poorly adapted physical activity may increase the risk of discontinuation, injury, and reduced motivation, whereas a gradual increases in exercise intensity may facilitate long-term engagement [6,7,17,18].

Research findings indicate that the absence of depression is not synonymous with complete mental well-being or a high quality of life. A man may not meet the criteria for depression yet still experience chronic fatigue, a decline in physical performance, lowered self-esteem, social withdrawal, and a diminished sense of purpose or life satisfaction [7,12,19].

Potential mechanisms underlying the effects of physical activity

The impact of physical activity on mental well-being is multidimensional [9,12,19].

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Biological mechanisms

Literature shows that improvements in body composition, specifically the reduction of fat mass and the preservation of muscle mass, can support mobility, independence, and psychosocial functioning. It has been shown that weight loss achieved through exercise interventions improves more domains of quality of life than testosterone therapy alone, thereby contributing to better metabolic and functional health [19-23]. While the reduction of chronic inflammation and the improvement of the physiological stress response are biologically plausible mechanisms, their mediating role in men with LOH has not been directly confirmed [1,2,9,19,23]. Conversely, regular physical activity is associated with a reduction in symptoms of depression, anxiety, and distress [7-9,15,21-26]. Indirect improvements in sleep quality are also possible, though available studies do not allow this to be regarded as a conclusively confirmed mechanism [22,23,27].

Psychological mechanisms

Physical activity can support mental well-being by enhancing physical fitness, self-esteem, and the sense of competence and control over one's health. Regular engagement in physical activity may enhance a sense of agency, particularly when it leads to noticeable improvements in strength, physical capacity, or independence. However, these mechanisms are primarily regarded as probable mediating factors, as existing studies are characterized by methodological heterogeneity, are often cross-sectional in nature, and rarely directly test for causal mediation [9].

Findings from systematic reviews and meta-analyses indicate that exercise can reduce the severity of depressive symptoms, anxiety, and distress across various adult populations, including older adults [6,7,13-15]. Psychological benefits may stem from the interplay of several processes, such as a sense of agency, improved body image, reduced feelings of helplessness, distraction from negative thoughts, better emotional regulation, and increased motivation to adopt other health-promoting behaviors. Improvements in physical fitness and body composition may further support quality of life and psychosocial functioning [19,22].

However, it should be noted that these mechanisms have not been conclusively confirmed in men with LOH. Available findings come primarily from studies involving the

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general population, older adults, and patients with depression or obesity; therefore, caution is required when directly applying them to men with LOH [9,19,23].

Social mechanisms

Physical activity can also support mental well-being by increasing interpersonal contacts, strengthening the sense of belonging, and facilitating access to social support. Group-based activities, group walking, recreational physical activity, and amateur sports create opportunities for regular interaction, the exchange of experiences, and mutual motivation to remain active. In older adults, participation in such forms of physical activity may contribute to enhancing self-esteem, reduce social isolation, and improve social functioning, potentially leading to a better quality of life and enhanced mental well-being [16,28].

Support from a partner, family, or social group may facilitate the initiation of exercise and reduce the risk of discontinuation. However, this relationship may be bidirectional, as individuals with better mental health and greater social resources may be more likely to engage in physical activity [28].

Existing studies on social mediators and moderators vary in their methodology, and many are observational in nature. Consequently, it is impossible to definitively confirm that social support acts as a causal mediator in the impact of physical activity on mental health [9]. Furthermore, as these findings primarily concern the general population and older adults, caution is required when directly applying them to men with confirmed LOH [9,16,28].

Physical activity, testosterone: metabolic and psychosocial functioning

Obesity – type 2 diabetes – testosterone levels

The relationships between physical activity, androgen status, and metabolism in men are complex and partly bidirectional. Obesity and type 2 diabetes often coexist with reduced testosterone levels, while androgen deficiency may be associated with reduced muscle mass, increased body fat, and impaired metabolic function. However, low testosterone levels in men with obesity do not always indicate permanent hypogonadism. They may reflect a functional, potentially reversible impairment of the hypothalamic-pituitary-testicular axis associated with excess body weight, chronic diseases, sleep disturbances, and pharmacological treatment

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[2,29,30]. Excessive accumulation of visceral adipose tissue plays an important role in obesity-related disturbances of androgen metabolism and is associated with insulin resistance and chronic low-grade inflammation [2,3,29].

One proposed mechanism involves increased aromatase activity in adipose tissue, leading to greater conversion of testosterone to estradiol, which may suppress the hypothalamic-pituitary-testicular axis through negative feedback. In addition, pro-inflammatory cytokines and adipokines associated with obesity may disrupt hypothalamic-pituitary-gonadal (HPG) axis regulation, contributing to functional reductions in gonadotropin and testosterone secretion [3,29]. Furthermore, obesity and insulin resistance may be associated with reduced sex hormone-binding globulin (SHBG) levels, affecting total testosterone concentrations and the interpretation of hormonal test results [3,29]. These mechanisms are multifactorial, and their relative contributions to the development of obesity-related hypogonadism remain incompletely understood [2,3,29].

Physical activity can influence body composition and physical performance and may promote increased testosterone levels, although the hormonal effects are inconsistent [23]. Therefore, lifestyle modification and the treatment of comorbidities form the basis of management for men with obesity or diabetes and low testosterone. Testosterone therapy should be considered only after confirming symptomatic hypogonadism, rather than as a routine treatment for metabolic disorders.

Aerobic training and testosterone levels

Aerobic training improves cardiorespiratory fitness, glycemic control, and body composition, thereby potentially mitigating factors associated with a functional decline in testosterone levels. A meta-analysis by Healy et al. [23] indicated a potential increase in testosterone levels among individuals with obesity or type 2 diabetes; however, the results were inconsistent and depended on participant characteristics, the exercise program, changes in body mass, and the hormonal assay methods used. Aerobic training has not been shown to lead to a clinically significant and sustained increase in testosterone in all men. The primary clinical significance of aerobic training lies in improvements to fitness, metabolism, and cardiovascular health, while its impact on testosterone remains a potential secondary effect.

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Resistance training – muscle strength – psychosocial functioning

Resistance training can attenuate the loss of muscle mass and strength, improve mobility, and reduce fatigue in older men. Functional benefits may support quality of life and mental well-being, independent of changes in testosterone levels. Studies have shown that comprehensive interventions combining resistance training, testosterone, and additional nutritional support were associated with improved physical function and reduced fatigue. However, due to the multicomponent nature of these interventions, the effects of individual elements cannot be isolated. These findings pertain to specific groups of older men and should not be generalized to all patients with LOH [2,20,31].

The importance of psychosocial functioning is supported by studies indicating an association between andropausal symptoms and limitations in occupational functioning, presenteeism, and poorer mental health; however, their cross-sectional design does not allow conclusions to be drawn regarding the effectiveness of physical activity interventions [32-35]. These findings suggest that greater symptom severity may be associated with reduced capacity to perform occupational duties, impaired daily functioning, and increased psychological burden. Nevertheless, the direction of causality cannot be determined, as poor mental health and chronic diseases can both exacerbate reported symptoms and result from them.

Available findings suggest that various forms of physical activity may support mental well-being through partially distinct functional, metabolic, psychological, and social mechanisms (Table 1). However, given the limited number of studies conducted specifically on men with confirmed LOH, the observed associations should be interpreted with caution.

Table 1. The potential significance of various forms of physical activity for the mental well-being of middle-aged and older men

Type of activity	Potential significance for mental well-being	Sources
Aerobic training	Reduction of depressive symptoms, improvement in physical performance, potential effect on testosterone in selected populations	[6,7,23]
Resistance training	Improvement in strength, self-esteem, fitness, and quality of life	[21,25,26]
Mixed training	Combines metabolic, functional, and psychological effects	[20,28]
Group activity	Social support, reduction of isolation, improvement of social functioning	[9,16]
Daily/recreational activity	Preservation of function, improved mood, accessibility for individuals with lower physical capacity	[12]

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Physical activity and testosterone therapy

Physical activity and testosterone therapy are not interchangeable interventions. Physical activity is a widely recommended component of a healthy lifestyle, whereas hormonal treatment requires the presence of consistent clinical symptoms, repeatedly low testosterone levels, and an assessment of contraindications and risks [4,5]. A meta-analysis conducted by Hudson et al. has shown that the symptomatic benefits of testosterone therapy vary depending on patient characteristics and the endpoints evaluated [11]. In the TRAVERSE trial, testosterone therapy was non-inferior to placebo regarding the incidence of major adverse cardiovascular events in appropriately selected men; however, this finding should not be equated with complete safety across all populations [36].

Physical activity can improve fitness, strength, mobility, body composition, and mental well-being, regardless of changes in testosterone levels or decisions regarding hormone therapy [8,9,15,21,28,37]. It should not be defined as a treatment for andropause but rather as an intervention supporting the metabolic, functional, and mental health of middle-aged and older men [4,5]. Exercise does not replace endocrine diagnostics; symptoms suggestive of hypogonadism require clinical assessment and repeated testosterone measurements, taking into account obesity, chronic diseases, sleep disorders, and other potential causes of the symptoms [2,4,27,29].

Practical implications

In middle-aged and older men presenting with low mood, fatigue, sleep disturbances, or a decline in physical function or quality of life, a comprehensive assessment is required; this should encompass clinical symptoms, repeated testosterone measurements, chronic diseases, obesity, diabetes, sleep disorders, current medications, and psychosocial factors [1-5,27,29]. The activity program should be individualized, taking into account baseline fitness, comorbidities, patient preferences, and safety. A combination of aerobic exercise, resistance training, and daily physical activity appears to be the most justified approach. These interventions can reduce the severity of depressive symptoms, anxiety, and distress, while improving quality of life, muscle strength, functional status, and social relationships [6-10,13-16,19,25,26,28].

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According to the WHO and ACSM recommendations, the target physical activity program should comprise 150-300 minutes of moderate-intensity aerobic exercise per week or 75-150 minutes of vigorous-intensity aerobic exercise, supplemented by resistance training targeting the major muscle groups and performed at least 2-3 times per week. For men aged 65 years and older, additional multicomponent neuromotor exercise is recommended, focusing primarily on balance, coordination, and functional strength training, performed at least three times per week, with intensity adjusted to the individual's physical capabilities [38,39]. However, it should be emphasized that these recommendations apply to the general adult and older adult populations, and their effectiveness in improving psychological well-being among men with clinically confirmed LOH has not yet been adequately established in intervention studies. Benefits can be observed even with activity levels below standard population recommendations; therefore, gradual increases in physical activity and support for long-term adherence have practical importance [17,18,37].

The effect of exercise on testosterone levels is inconsistent and should not be the primary goal of an intervention [23]. Efficacy should be assessed primarily through changes in mood, fatigue, sleep, physical performance, body composition, and quality of life. Testosterone therapy may be considered only for appropriately diagnosed patients and is not a substitute for physical activity [4,5,11,22,36].

Discussion of the review results

The results of this review indicate that physical activity can be a significant factor in supporting the mental well-being of men experiencing symptoms associated with the age-related decline in androgens. However, its potential significance should not be interpreted solely as a consequence of changes in testosterone levels. Available evidence supports a multidimensional impact of physical activity through improvements in physical fitness, body composition, sleep quality, metabolic functioning, self-esteem, and social participation rather than a simple hormonal mechanism [6-10,15,16,19,23,25,26].

Interpreting symptoms attributed to andropause requires particular caution. Low mood, fatigue, sleep disturbances, reduced energy, and a decline in quality of life are not specific to hypogonadism. They may also occur in the context of obesity, type 2 diabetes, chronic diseases, medication use, chronic stress, or psychosocial issues [1,2,27,29]. Furthermore, the relationship between testosterone deficiency and depression may be bidirectional, and current data do not

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support a simple causal relationship [1]. This justifies the use of a biopsychosocial model and the distinction between a physiological decline in testosterone levels and symptomatic hypogonadism confirmed both clinically and through laboratory testing [3-5].

Results from systematic reviews and meta-analyses have consistently shown that physical activity can reduce the severity of depressive symptoms, anxiety, and distress [6-8,10,13-15]. However, this does not imply that the magnitude of the effect will be the same in patients with LOH. Most available studies have involved general populations, the elderly, or patients with depression, obesity, or chronic diseases, whereas direct intervention studies focusing on the mental well-being of men with confirmed LOH remain scarce. It is worth noting that most meta-analyses focus on the general population or individuals with depression, rather than specifically on patients with LOH, which limits the direct extrapolation of the findings. Consequently, conclusions regarding this group are partly based on indirect evidence. The literature reviewed indicates that well-being may depend on both the type of activity and the context in which it is undertaken.

Aerobic and resistance training, as well as multicomponent interventions, have been associated with improvements in mood, quality of life, muscle strength, and functional performance [19,20,25,26,28]. At the same time, no single optimal form of exercise suitable for all patients has been identified. Factors such as participant preferences, health status, recovery capacity, level of supervision, and consistency may play a role. Findings regarding domain-specific activity also suggest that voluntary recreational activity may differ in its psychological effects from occupational physical activity or activity performed with a low sense of control [12].

Energy expenditure alone does not fully capture the psychological meaning of physical activity. Improved physical functioning may be a key mechanism; maintaining strength, mobility, and independence can help limit fatigue, dependence on others, and withdrawal from social activities. Resistance training has been shown to have a beneficial effect on muscle strength, exercise capacity, quality of life, and certain mental health indicators in older adults [25,26]. Intervention studies involving older men have also indicated improvements in physical performance and reductions in fatigue [20,21]. However, these results should be interpreted with caution, as the interventions involved a combination of exercise, testosterone, and supplementation. Consequently, it is not possible to attribute all the observed effects solely to the training itself.

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A similar limitation applies to the relationship between exercise and testosterone levels. A meta-analysis involving individuals with obesity or type 2 diabetes suggests that aerobic training may lead to increased testosterone levels; however, the results were inconsistent and depended on factors such as weight loss, program characteristics, and baseline metabolic status [23]. There is no evidence to support the claim that regular exercise causes a clinically significant and sustained increase in testosterone in all ageing men. The primary value of physical activity lies in improvements to metabolic health, physical fitness, and body composition, whereas changes in the hormonal profile may be a secondary effect.

From a psychosocial perspective, improvements in the sense of agency, self-esteem, body image, and control over one's health may be significant. However, a synthesis of mediation studies indicates that these mechanisms have not yet been conclusively confirmed as causal mediators [9]. Similar caution applies to the impact of group activity. Participation in such activities can enhance social contacts, the sense of belonging, and access to support [16,28], yet this relationship is likely bidirectional: individuals with greater social support may also be more likely to engage in such activities (Table 2).

Table 2. Potential factors modifying the relationship between physical activity and the mental well-being of men with symptoms associated with the age-related decline in androgens

Potential modifying factor	Possible significance for the interpretation of results	Sources
Age and baseline fitness	They may influence exercise tolerance, functional capacity, comorbidities, and response to exercise intervention.	[4,5,28]
Obesity and body composition	Obesity may co-occur with functional testosterone decline, poorer metabolic health, and lower quality of life; weight reduction may mediate some of the observed benefits.	[2,19,22,23,29]
Type 2 diabetes	It may affect androgen balance, physical performance, and the metabolic response to training.	[23,29]
Sleep and obstructive sleep apnea	Sleep disturbances may co-occur with reduced testosterone levels, fatigue, and impaired mood, complicating the assessment of the independent effects of physical activity.	[27]
Type and context of activity	Aerobic, resistance, recreational, and group activities can operate through distinct physiological, psychological, and social mechanisms.	[6,9,12,16,25,26]
Sexual functioning	Sexual dysfunction may co-occur with low self-esteem and reduced quality of life, but it has not been conclusively confirmed as a moderator of the effects of physical activity.	[5,11]

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Social support	It may foster the initiation and maintenance of activity and reinforce the psychosocial benefits of participation, although the relationship may be bidirectional.	[9,16]

An important finding of the review is the distinction between the roles of physical activity and testosterone therapy; these interventions are not interchangeable. Hormone therapy should be considered for patients presenting with relevant symptoms and consistently low testosterone levels, once reversible causes of the condition have been ruled out [3-5]. A meta-analysis of individual patient data demonstrated varying benefits of testosterone therapy, depending on patient characteristics and the endpoints assessed [11]. The TRAVERSE trial provided data on cardiovascular safety in a specific population of appropriately selected men but does not justify regarding the therapy as risk-free across all groups [36]. Physical activity, on the other hand, may provide functional and psychological benefits regardless of the decision to initiate testosterone therapy.

The literature reviewed has several significant limitations. Studies vary in their definitions of testosterone deficiency, inclusion criteria, types of activity, intervention durations, and the tools used to assess well-being. Some data originate from cross-sectional studies, which do not allow for the determination of the direction of causality. This applies, for instance, to studies linking andropausal symptoms with presenteeism and impaired occupational functioning [32-35]. Furthermore, the concept of andropause is applied inconsistently, potentially conflating men with confirmed hypogonadism with individuals reporting non-specific symptoms of ageing.

Further randomized trials are needed, involving men with clearly defined LOH, in which physical activity is evaluated as a stand-alone intervention. Future research should consider hormonal outcomes as well as depression, anxiety, sleep, self-esteem, quality of life, social functioning, and work ability. It is also necessary to determine which types and doses of activity are most effective, what factors influence adherence to recommendations, and whether improvements in well-being are mediated by changes in fitness, body weight, sleep, or social support.

Physical activity is a valid component of the comprehensive management of men with symptoms associated with the age-related decline in androgens. However, it should not be presented as a specific treatment for andropause or as a substitute for the diagnosis of hypogonadism. Its primary value lies in supporting mental, metabolic, functional, and social health within an individualized biopsychosocial model.

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Conclusions

Available studies indicate that physical activity can support the mental well-being of middle-aged and older men experiencing symptoms associated with the age-related decline in androgens. Evidence derived primarily from general older-adult populations and patients with chronic diseases suggests that physical activity may reduce depressive and anxiety symptoms and psychological distress, while improving quality of life, physical fitness, and social functioning [6-10,13-16,19,25,26,28]. These benefits may result from interactions among biological, psychological, and social mechanisms, although their roles as causal mediators have not been conclusively established [9].

Physical activity should be considered part of comprehensive, individualized biopsychosocial management rather than a specific treatment for LOH. Given the nonspecific nature of the symptoms, an interdisciplinary approach involving a primary care physician, urologist or endocrinologist, and, where indicated, a psychiatrist, psychologist, and physiotherapist is warranted. Management should include assessment of hormonal status, metabolic disorders, mental health, and functional fitness, alongside individualized recommendations for aerobic activity, resistance training, and everyday movement, in accordance with the WHO and ACSM population-level guidelines [3-5,38,39].

The effects of physical activity on testosterone levels depend on population characteristics and the intervention applied, and the available evidence does not support considering exercise a method that leads to sustained normalization of testosterone levels in all men [23]. Physical activity does not replace the diagnostic evaluation of hypogonadism or testosterone therapy when appropriately indicated [3-5]. Assessment of treatment outcomes should include hormonal parameters as well as mood, fatigue, sleep quality, physical fitness, body composition, and social functioning.

Research objectives

Interpretation of the available findings is limited by heterogeneity in the study populations, differences in the criteria used to diagnose testosterone deficiency, variations in interventions, and the small number of studies directly assessing the psychological well-being of men with clinically and biochemically confirmed LOH. Further randomized controlled trials (RCTs) are needed in which physical activity is evaluated as a stand-alone intervention,

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allowing its effects to be determined independently of concurrent hormone therapy, supplementation, and other interventions. Future studies should incorporate standardized hormonal assessments, including repeated morning measurements of total testosterone, LH, FSH, and SHBG, as well as free testosterone assessment where appropriate, and validated psychometric scales measuring depressive and anxiety symptoms, psychological well-being, and quality of life. Training parameters should also be standardized according to the FITT principles, adherence should be monitored, and the durability of outcomes should be assessed. Of particular importance is determining whether potential improvements in psychological well-being are associated with hormonal changes or mediated by changes in physical fitness, body composition, sleep quality, self-efficacy, and social support.

Physical activity represents a modifiable health-related factor, as its type, frequency, intensity, and duration can be tailored to the individual capabilities and health needs of men [38,39]. Its potential benefits for psychological well-being include reductions in depressive and anxiety symptoms, as well as improvements in quality of life, functional fitness, self-esteem, and social participation. However, the available evidence is derived predominantly from studies involving populations other than men with confirmed LOH [6-10,16,19,25,26,28]. These benefits may arise from the interplay of biological, psychological, and social mechanisms that are not necessarily directly associated with changes in testosterone concentrations; however, their mediating roles require further investigation [9,23]. Physical activity may therefore represent an important component of comprehensive, individualized strategies to support the psychological well-being of ageing men. Nevertheless, its effectiveness in this specific clinical population requires confirmation in studies directly involving patients with LOH.

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