DOI: 10.7860/JCDR/2026/84615.22415

Original Article

Psychiatry/Mental Health Section

Relationship Between Serum Testosterone Levels, Severity of Dependence, Impulsivity and Craving in Alcohol Dependent Males: A Prospective Observational Study

VIGNESH RAJA[1], ARAVINDH MANOGARAN[2], KAILASH SURESHKUMAR[3], SHABEEBA Z KAILASH[4]

ABSTRACT

Introduction: Alcohol dependence is a chronic relapsing disorder characterised by compulsive alcohol use, craving, and withdrawal symptoms. Emerging evidence suggests testosterone may influence craving intensity and impulsivity during early abstinence.

Aim: To determine relationship between serum testosterone, severity of dependence, impulsivity, and craving in males with alcohol dependence.

Materials and Methods: The present single-centre, prospective observational study was conducted in the Psychiatry Outpatient Department (OPD) of Chettinad Hospital & Research Institute, Chennai,Tamil Nadu, India (May 2024-June 2025); 55 male patients (18-59 years) with International Classification of Diseases (ICD)-11 alcohol dependence (6C40.2) were enrolled after written informed consent and Institutional Human Ethics Committee (IHEC) approval (IHEC-I/2824/24; 02/05/2024). Serum total testosterone (CLIA) was measured on days 1 and 7, alcohol craving (PACS) on days 1 and 7, dependence severity (SAD-Q), impulsivity (BIS-11) and sociodemographics; analyses used Statistical Package for Social Sciences (SPSS) v26 with Shapiro-Wilk tests for normality, independent-t/Analysis of Variance (ANOVA) for group comparisons, paired-t for within-person change, and adjusted (partial) Pearson correlations (two-tailed α=0.05).

Results: Craving scores were significantly higher among patients aged 40-60 years (mean=24.1, p=0.001). Impulsivity scores were significantly elevated in lower socioeconomic backgrounds (mean=67.1, p=0.021). On day 1 of abstinence, craving increased with severity of dependence, ranging from 19.2 (mild) to 23.3 (severe), with statistically significant differences (p=0.002), while all groups showed significant craving reduction by day 7 (p<0.001). Serum testosterone levels declined from day 1 to day 7, particularly in moderate and severe groups (p=0.014 and p=0.001, respectively), though between-group differences remained non-significant. A significant positive correlation was found between testosterone and craving on day 7 (r=0.382, p=0.004), and reduction in testosterone strongly correlated with reduction in craving over 7-day period (r=0.529, p<0.001).

Conclusion: The study found a significant positive correlation between changes in serum testosterone levels and craving during early abstinence in alcohol-dependent males. These findings suggest that testosterone may serve as a potential biomarker for craving intensity.

Keywords: Alcohol-related disorders, Biomarkers, Substance withdrawal syndrome

INTRODUCTION

Alcohol dependence remains one of the most prevalent and debilitating substance use disorders worldwide, characterised by compulsive alcohol consumption, tolerance, withdrawal symptoms, and significant impairment in personal, social, and occupational domains [1]. Globally, alcohol use contributes to over 3 million deaths annually and accounts for 5.1% of the global burden of disease and injury, with a disproportionately higher impact on men [2]. In India, the National Mental Health Survey (2015-2016) reported a lifetime prevalence of 9% for alcohol use disorders among adult males, with significant regional and socioeconomic variability [3,4]. Severe alcohol dependence is linked to persistent alterations in the mesolimbic dopamine system, glutamatergic excitotoxicity, and HPA axis dysregulation, which collectively contribute to compulsive alcohol-seeking behaviour [5,6].

Craving, defined as an intense desire or urge to consume alcohol, is a core feature of alcohol dependence and a major contributor to relapse during abstinence [5]. The Penn Alcohol Craving Scale (PACS) and other validated tools have established craving as a dynamic and measurable construct that varies with abstinence duration, environmental cues, and neurobiological changes [6]. Craving intensity has been shown to peak during early withdrawal and taper off over time; however, individual variations in craving trajectories suggest involvement of underlying neurochemical and hormonal mechanisms [7]. Among the neuroendocrine factors implicated in addiction-related craving and relapse, testosterone has received increasing attention due to its influence on mood, behaviour, and reward processing [8]. testosterone, the primary male androgen hormone, plays a crucial role in modulating neurobehavioral traits such as aggression, impulsivity, and risk-taking-traits often associated with the initiation and maintenance of substance use disorders [9]. testosterone also interacts with the Hypothalamic-Pituitary-Gonadal (HPG) axis and the dopaminergic reward pathways, both of which are disrupted in alcohol dependence [10].

Aubele T et al., demonstrated that testosterone enhances the sensitivity of mesolimbic dopaminergic neurons, thereby intensifying responses to rewarding stimuli, including drugs and alcohol [11]. In animal models, testosterone administration has been shown to increase ethanol consumption and preference, suggesting a facilitatory effect on alcohol-seeking behaviour [12,13]. Conversely, testosterone depletion reduces substance-related behaviours, highlighting its potential regulatory role in addiction vulnerability. Clinical studies have

also begun to elucidate the relationship between testosterone levels and alcohol use behaviours in humans. Chronic alcohol consumption has been associated with significant alterations in serum testosterone levels, often leading to hypogonadism in long-term users due to hepatic dysfunction, suppression of luteinising hormone, and direct testicular toxicity [14]. One of the few studies directly examining this relationship, conducted by Heberlein and colleagues (2016) [15], evaluated testosterone and Brain-derived Neurotrophic Factor (BDNF) levels in male patients undergoing alcohol withdrawal. The study found a significant positive correlation between serum testosterone and craving scores, particularly during the early abstinence period. These findings suggested that testosterone could serve not only as a biomarker of withdrawal severity but also as a potential modulator of craving intensity. Such associations underscore the need for further research into testosterone dynamics and their behavioural correlates in alcohol dependence [15].

In addition to craving, impulsivity is another critical trait in the pathophysiology of alcohol use disorders. Impulsivity, broadly defined as the tendency to act prematurely or without adequate forethought, is a multidimensional construct encompassing attentional, motor, and non-planning components [16]. Elevated impulsivity has been linked to early initiation of substance use, higher consumption patterns, poor treatment adherence, and increased relapse rates [17]. The Barratt Impulsiveness Scale (BIS-11) is widely used to assess impulsivity and has shown consistent associations with alcohol use severity [18]. Importantly, testosterone has also been implicated in the modulation of impulsivity. Higher endogenous testosterone levels have been associated with increased motor and risk-taking impulsivity in both clinical and non-clinical populations [19]. In alcohol-dependent individuals, elevated impulsivity may mediate the relationship between testosterone and craving, thereby influencing relapse potential [20]. However, studies examining the interplay between testosterone, impulsivity, and craving in this population remain scarce.

Understanding the neuroendocrine correlates of craving and impulsivity during the early abstinence period is of particular clinical relevance. The first week of alcohol detoxification is a critical window during which patients are highly vulnerable to withdrawal symptoms, psychological distress, and relapse. Identifying biological markers that predict craving trajectories can facilitate timely interventions, optimise treatment strategies, and reduce relapse risk [21]. Against this background, the aim of the present study was to determine the relationship between serum testosterone levels and the severity of dependence, impulsivity, and craving in male patients with alcohol dependence.

MATERIALS AND METHODS

The present single-centre, hospital-based, prospective observational study was conducted in the Outpatient Department of the Department of Psychiatry, Chettinad Hospital and Research Institute, Chennai, Tamil Nadu, India between May 2024 and June 2025. The study received approval from the Institutional Human Ethics Committee (IHEC-I/2824/24 dated 02/05/2024). Each participant, along with their attendant when applicable, was provided with a Participant Information Sheet (PIS) translated into their local language. The information was also explained verbally to ensure clear understanding and voluntary agreement. Written informed consent was obtained prior to enrolling participants in the study.

Inclusion and Exclusion criteria: The study included male patients between 18 and 59 years of age with alcohol dependence (ICD-11 6C40.2) [22]. However, patients with serious medical illnesses, co-morbid psychiatric disorders such as intellectual disability, liver cirrhosis, or those presenting with complicated alcohol withdrawal states such as delirium tremens were excluded.

Sample size calculation: Based on Heberlein A et al., (2016) [15], which reported a correlation of r=0.25 between testosterone levels and craving during alcohol withdrawal, the sample size was calculated using a two-tailed test with an alpha of 0.05 and power of 80%. The minimum required sample size was 49 participants. After accounting for a 10% margin to compensate for potential dropouts or incomplete data, the final sample size was rounded to 55 participants. The patients were enrolled using nonprobability sampling – purposive/convenience sampling technique.

Study Procedure

Sociodemographic information was obtained using a structured proforma. Data included age, marital status, education, occupation, socioeconomic status (as per Modified Kuppuswamy Scale) [23], and area of residence (urban, semiurban, or rural). On day 1 of abstinence, each participant was evaluated for the severity of alcohol dependence, alcohol craving, and impulsivity. The Severity of Alcohol Dependence Questionnaire (SAD-Q) was used to assess the severity of dependence. This 20-item instrument covers five domains, with each item scored on a 4-point Likert scale [24]. The total score ranges from 0 to 60 and is interpreted as follows: scores between 0-15 indicate mild dependence, 16-30 indicate moderate dependence, and scores between 31-60 reflect severe dependence [25]. Craving was assessed using the Penn Alcohol Craving Scale (PACS) [6], a 5-item self-reported instrument that evaluates the frequency, intensity, and duration of craving over the past week. Each item is rated from 0 to 6, yielding a total score between 0 and 30, with higher scores indicating greater craving intensity [26]. The PACS was administered on both day 1 and day 7 of abstinence to track changes over time. Impulsivity was measured using the Barratt Impulsiveness Scale (BIS-11), a 30-item tool designed to assess impulsivity across three domains: attentional impulsivity, motor impulsivity, and non-planning impulsivity [18]. Each item is scored on a 4-point scale, and higher scores denote greater impulsivity.

Venous blood samples were collected from participants on day 1 and day 7 of abstinence between 8:00 AM and 10:00 AM to control for diurnal variation in hormone levels. Approximately 5 mL of venous blood was drawn under aseptic conditions. Serum was separated by centrifugation and stored at -20°C until analysis. Total serum testosterone levels were measured using automated Chemiluminescent Immunoassay (CLIA) method (Beckman Coulter Access Immunoassay System). The reference range for adult males was considered as 1.75 to 7.81 ng/mL [27]. All laboratory analyses were performed in the institutional central laboratory, adhering to internal quality control standards.

STATISTICAL ANALYSIS

Data were entered into Microsoft Excel and analysed using the SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Normality of continuous variables was assessed using the Shapiro–Wilk test, complemented by visual inspection of Q–Q plots and histograms; the data was normally distributed. Descriptive statistics were computed for all variables. Continuous variables were presented as mean and Standard Deviation (SD) (all normally distributed), while categorical variables were summarised as frequencies and percentages. The severity of alcohol dependence (SAD-Q), impulsivity (BIS-11), and craving scores (PACS) were compared across sociodemographic categories using independent-sample t-tests or one-way ANOVA, depending on the number of groups. Paired t-tests were used to assess within-group changes in serum testosterone and PACS scores from day 1 to day 7 of abstinence. Correlation analyses were performed using Pearson's correlation coefficient to determine the relationship between serum testosterone levels and PACS scores on day 1 and day 7, as well as changes between day 1 and day 7. A p-value of less than 0.05 was considered statistically significant for all analyses (two tailed).

RESULTS

Among the 55 male patients {mean (SD) age was 40.6 years (9.9)} with alcohol dependence, the Severity of Alcohol Dependence (SAD-Q), craving (PACS), and impulsivity (BIS) scores were analysed across various sociodemographic categories [Table/Fig-1]. No statistically significant differences were found in SAD-Q scores across age groups (p=0.257), education levels (p=0.776), occupation (p=0.490), socioeconomic status (p=0.391), residence (p=0.066), or marital status (p=0.597). However, PACS scores differed significantly across age groups, with the highest mean craving observed in the 40-60 years group (24.1±1.8), and the difference was statistically significant (p=0.001). Impulsivity scores (BIS) showed a significant difference with socioeconomic status (p=0.021), where individuals from the lower socioeconomic group had higher mean impulsivity scores (67.1±5.3) compared to the middle (63.3±4.2) and upper (65.5±3.3) groups. No other sociodemographic factors significantly influenced craving or impulsivity scores.

Serum testosterone levels were measured on day 1 and day 7 of abstinence among patients with varying severity of alcohol dependence [Table/Fig-4,5]. On day 1, mean testosterone levels were comparable across the mild (4.2±2.2 ng/mL), moderate (4.8±2.1 ng/mL), and severe (4.2±1.9 ng/mL) groups, with no significant difference (p=0.639). By day 7, testosterone levels declined across all groups-3.8±1.4 ng/mL in the mild group, 3.0±1.8 ng/mL in the moderate group, and 2.9±1.2 ng/mL in the severe group—with the between-group difference remaining statistically non-significant (p=0.400). However, within-group comparisons revealed a significant reduction in testosterone levels from day 1 to day 7 in the moderate (p=0.014) and severe (p=0.001) groups, while the decrease in the mild group was not significant (p=0.740). Additional analysis found that the serum testosterone levels on day 1 (r=-0.202; p=139) and day 7 (r=-0.169; p=218) were not correlated with the age (years) at presentation of patients with alcohol dependance.

The total BIS score showed no significant difference across the mild (62.8±3.6), moderate (66.2±5.5), and severe (64.0±4.4) groups

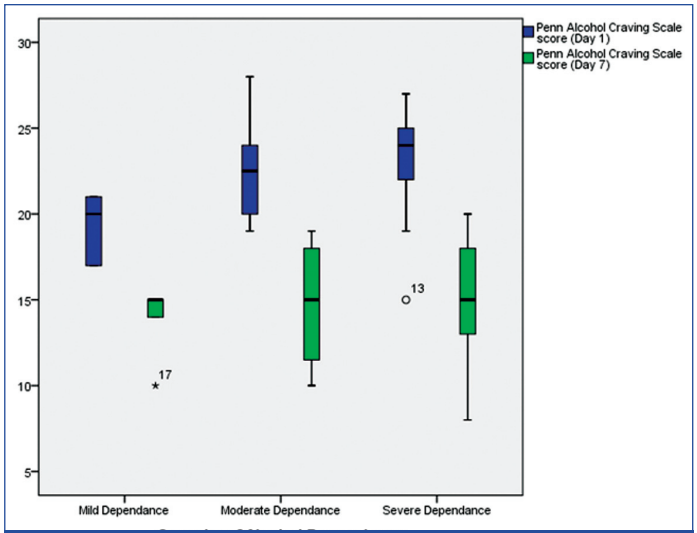
Variables		n (%)	Alcohol dependence (SAD-Q)		Craving (PACS)		Impulsivity (BIS)	
			Mean (SD)	p-value	Mean (SD)	p-value	Mean (SD)	p-value
Age (in years)	18 to 25	3 (5.5)	29.7 (15.0)	0.257	23.0 (2.6)	0.001*	63.7 (3.2)	0.782
	25 to 40	29 (52.7)	31.7 (9.1)		21.4 (2.6)		64.9 (5.3)	
	40 to 60	23 (41.8)	35.3 (7.0)		24.1 (1.8)		64.1 (4.2)	
Education	Illiterate	1 (1.8)	34.0 (0.0)	0.776	26.0 (0.0)	0.180	62.0 (0.0)	0.703
	Primary to high school	16 (29.1)	31.8 (8.3)		23.3 (2.5)		63.9 (4.9)	
	Intermediate/ Diploma and above	38 (69.1)	33.6 (9.0)		22.3 (2.6)		64.9 (4.8)	
Occupation	Unemployed	3 (5.5)	29.7 (15.0)	0.490	23.0 (2.6)	0.808	63.7 (3.2)	0.745
	Employed	52 (94.5)	33.3 (8.4)		22.6 (2.7)		64.6 (4.8)	
SES	Lower	16 (29.1)	31.5 (7.6)	0.391	23.8 (2.4)	0.119	67.1 (5.3)	0.021*
	Middle	35 (63.6)	34.2 (8.4)		22.1 (2.7)		63.3 (4.2)	
	Upper	4 (7.3)	29.3 (14.9)		22.8 (1.7)		65.5 (3.3)	
Residence	Urban	16 (29.1)	34.7 (5.5)	0.066	22.5 (2.8)	0.854	66.1 (4.9)	0.277
	Semiurban	26 (47.3)	30.2 (10.7)		22.5 (2.8)		63.7 (4.6)	
	Rural	13 (23.6)	36.8 (5.1)		23.0 (2.2)		64.2 (4.8)	
Marital status	Married	48 (87.3)	33.3 (8.6)	0.597	22.7 (2.7)	0.710	64.4 (4.6)	0.490
	Never married	7 (12.7)	31.4 (9.7)		22.3 (2.2)		65.7 (6.0)	

[Table/Fig-1]: Comparison of sociodemographic characteristics by alcohol dependence, craving and impulsivity.
SES: Socioeconomic status; SAD-Q: Severity of alcohol dependence questionnaire; PACS: Penn alcohol craving scale; BIS: Barratt impulsiveness scale; SD: Standard deviation

The PACS scores were assessed on days 1 and 7 of abstinence across varying severities of alcohol dependence [Table/Fig-2,3]. On day 1, mean craving scores increased with the severity of dependence: 19.2 (±2.0) in the mild group, 22.3 (±2.3) in the moderate group, and 23.3 (±2.5) in the severe group, with the difference being statistically significant (p=0.002). By day 7, craving scores declined across all groups-13.8 (±2.2), 14.9 (±3.4), and 14.9 (±3.2), respectively-with no statistically significant difference between the groups (p=0.757). Within-group comparisons from day 1 to day 7 showed significant reductions in craving scores across all levels of dependence (p<0.001).

Variables	Alcohol dependance				p-value
	Mild N=5	Moderate N=16	Severe N=34	Total N=55	
Penn alcohol craving scale score (Day 1), Mean (SD)	19.2 (2.0)	22.3 (2.3)	23.3 (2.5)	22.6 (2.6)	0.002*
Penn alcohol craving scale score (Day 7), Mean (SD)	13.8 (2.2)	14.9 (3.4)	14.9 (3.2)	14.8 (3.2)	0.757
p-value	<0.001*	<0.001*	<0.001*	<0.001*	

[Table/Fig-2]: Comparison of alcohol craving (day 1 and 7 of abstinence) by severity of alcohol dependance.
*Statistically significant at p<0.05

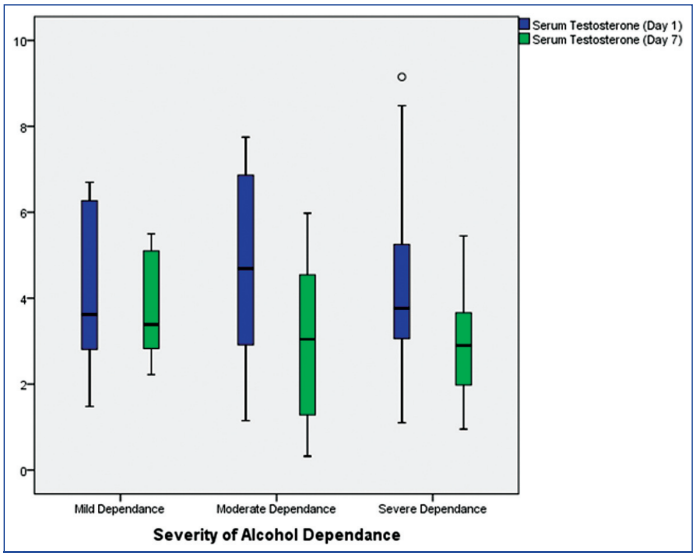


[Table/Fig-3]: Comparison of alcohol craving (day 1 and 7 of abstinence) by severity of alcohol dependance.

(p=0.226). Similarly, no significant differences were observed in the attention (p=0.895) and planning (p=0.770) facets across the groups. Although the motor impulsivity scores tended to be higher in the moderate group (23.2±2.6) compared to the mild (21.2±2.2)

Serum testosterone	Alcohol dependance				p-value
	Mild N=5	Moderate N=16	Severe N=34	Total N=55	
Serum testosterone (Day 1), Mean (SD)	4.2 (2.2)	4.8 (2.1)	4.2 (1.9)	4.4 (2.0)	0.639
Serum testosterone (Day 7), Mean (SD)	3.8 (1.4)	3.0 (1.8)	2.9 (1.2)	3.0 (1.4)	0.400
p-value	0.740	0.014*	0.001*	<0.001*	

[Table/Fig-4]: Comparison of serum testosterone levels (day 1 and day 7 of abstinence) by severity of alcohol dependance.
*Statistically significant at p<0.05



[Table/Fig-5]: Comparison of serum testosterone levels (day 1 and day 7 of abstinence) by severity of alcohol dependance.

and severe (21.5±2.2) groups, this trend approached but did not reach statistical significance (p=0.056). Overall, impulsivity levels did not significantly vary with the severity of alcohol dependence [Table/Fig-6] Impulsivity was not correlated with serum testosterone levels at day 1 (r=0.282; p=0.137) and day 7 (r=0.205; p=0.132).

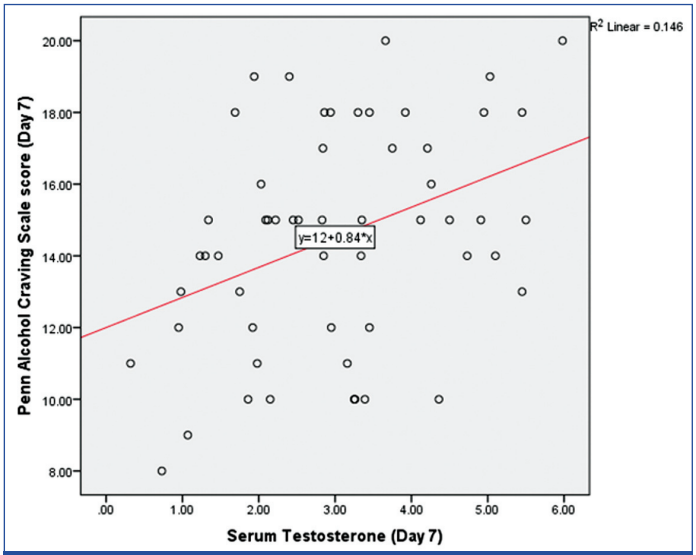
Parameters	Alcohol dependance				p-value
	Mild N=5	Moderate N=16	Severe N=34	Total N=55	
Barratt impulsiveness scale score - Total, Mean (SD)	62.8 (3.6)	66.2 (5.5)	64.0 (4.4)	64.5 (4.7)	0.226
Barratt impulsiveness scale score - Attention facet, Mean (SD)	11.8 (1.6)	12.1 (3.1)	11.7 (3.0)	11.8 (2.9)	0.895
Barratt impulsiveness scale score - Motor facet, Mean (SD)	21.2 (2.2)	23.2 (2.6)	21.5 (2.2)	22.0 (2.4)	0.056
Barratt impulsiveness scale score - Planning facet, Mean (SD)	29.8 (0.4)	30.9 (4.2)	30.8 (2.5)	30.7 (3.0)	0.770

[Table/Fig-6]: Comparison of impulsivity by severity of alcohol dependance.
*Statistically significant at p<0.05

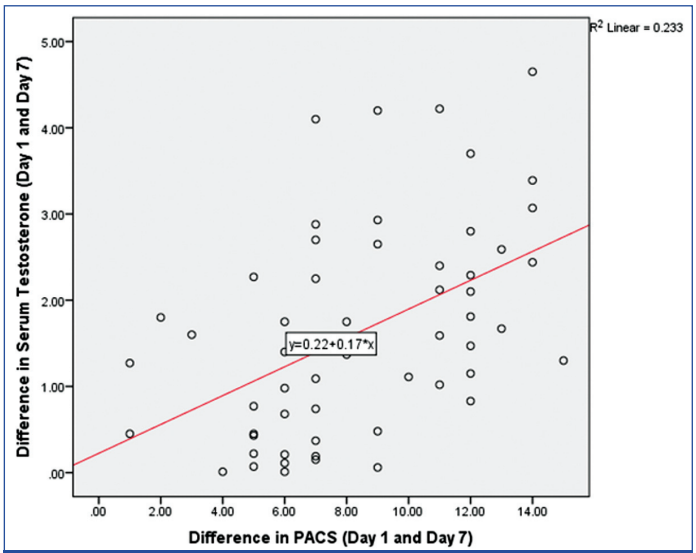
The correlation analysis between alcohol craving and serum testosterone levels revealed no significant association between PACS scores and testosterone levels on day 1 of abstinence (r=0.065, p=0.638) [Table/Fig-7]. However, a moderate positive correlation was observed on day 7, where higher craving scores were significantly associated with higher testosterone levels (r=0.382, p=0.004) [Table/Fig-8]. Notably, the change in craving scores from day 1 to day 7 showed a strong and statistically significant positive correlation with the change in serum testosterone levels over the same period (r=0.529, p<0.001), indicating that greater reductions in craving were associated with greater declines in testosterone [Table/Fig-9].

	Correlation coefficient	p-value
Penn alcohol craving scale score (Day 1) and serum testosterone (Day 1)	0.065	0.638
Penn alcohol craving scale score (Day 7) and serum testosterone (Day 7)	0.382	0.004*
Difference in PACS (Day 1 and Day 7) and difference in serum testosterone (Day 1 and Day 7)	0.529	<0.001*

[Table/Fig-7]: Correlation between alcohol craving and serum Testosterone (day 1 and day 7 of abstinence).
*Statistically significant at p<0.05; PACS: Penn alcohol craving scale



[Table/Fig-8]: Correlation between alcohol craving and serum testosterone (day 7 of abstinence).



[Table/Fig-9]: Correlation between difference in PACS (day 1 and day 7) and difference in serum testosterone (day 1 and day 7).

DISCUSSION

The findings of the present study highlight the interplay between serum testosterone levels, alcohol craving, and impulsivity among male patients undergoing early abstinence for alcohol dependence. Although the severity of alcohol dependence (as measured by the SAD-Q) did not significantly differ across age, education, occupation, socioeconomic status, residence, or marital status, craving levels (PACS scores) were significantly higher among older individuals aged 40-60 years. This aligns with Oslin DW et al., (2003) and Ramirez JJ et al., (2015) indicating that older individuals with chronic alcohol use may have stronger conditioned responses and craving cues due to longer exposure to drinking patterns and psychosocial stressors [28,29]. On the other hand, impulsivity scores (BIS) showed a significant association with socioeconomic

status, with lower SES groups reporting higher impulsivity. This is consistent with findings from Kozak K et al., (2019) and Patrick ME et al., (2012) which suggest that socioeconomic disadvantage is linked to poor impulse control and higher engagement in risk behaviours including substance use [30,31].

Analysis of craving scores across dependence severity revealed that individuals with higher SAD-Q scores reported significantly greater craving at baseline (day 1). This is in accordance with theoretical models and empirical data linking the severity of dependence with increased neuroadaptive changes in dopaminergic and glutamatergic systems, which drive compulsive drug-seeking and craving, as noted by Koob and Volkow (2010) [32]. However, by day 7 of abstinence, craving scores had declined across all groups, with no significant differences based on dependence severity. This trend supports the notion that acute withdrawal symptoms and the associated neurochemical imbalances begin to stabilise within the first week of detoxification [21], leading to a relative reduction in subjective craving.

Day 7 was selected as the primary endpoint to capture the transition from acute withdrawal to early abstinence while remaining aligned with typical inpatient detoxification trajectories. In uncomplicated alcohol withdrawal, symptom severity generally peaks within 24-72 hours and resolves over 4-7 days when managed with benzodiazepines using fixed-dose or symptom-triggered regimens; thus, day 7 provides a pragmatic time point at which acute physiological noise from withdrawal is minimised but clinically meaningful craving dynamics are already measurable. This choice is consistent with guideline-based care pathways and the expected time course of detoxification outlined by ASAM and primary-care reviews. To enhance interpretability, craving was also measured at baseline (day 1) to quantify early change; in subsequent work, we agree that adding a post-taper assessment (e.g., 24-48 hours after benzodiazepine discontinuation) would further isolate post-withdrawal craving from any taper effects. [33,34].

The current study also examined the pattern of serum testosterone levels during early abstinence. While baseline testosterone levels on day 1 did not differ significantly across severity groups, a significant within-group decline in testosterone was noted from day 1 to day 7 among individuals with moderate and severe dependence. This observation is in line with findings from Heberlein A et al., (2016) [15], who reported that testosterone levels in alcohol-dependent patients tend to be elevated during intoxication but decrease significantly during withdrawal. The decline is likely due to the downregulation of the HPG axis during the early withdrawal phase, as well as the reversal of alcohol-induced suppression of Luteinising Hormone–Releasing Hormone (LHRH) feedback loops [14,35]. Interestingly, despite variations in craving and testosterone dynamics, impulsivity scores (total and domain-specific) did not significantly differ across the severity of dependence. This may reflect a relatively stable trait-like component of impulsivity that does not necessarily vary with severity of dependence but could still contribute to initiation and relapse behaviours, as noted by Verdejo-García A et al., (2008) [36].

The most compelling finding of the study was the relationship between serum testosterone levels and craving. While no significant correlation was found between testosterone and craving on day 1 of abstinence, a moderate positive correlation emerged by day 7, indicating that patients with higher testosterone levels also reported higher craving scores at this stage. More importantly, the change in testosterone levels from day 1 to day 7 showed a strong positive correlation with the change in PACS scores, suggesting that greater reductions in testosterone were associated with greater reductions in craving. These findings provide empirical support to the hypothesis that testosterone may play a modulatory role in craving during early alcohol withdrawal [37]. Testosterone has been shown to interact with neural circuits involved in reward processing, particularly the mesolimbic dopamine system [11]. Welker KM et al., (2015) indicated that testosterone can increase dopaminergic activity and enhance reward sensitivity, potentially amplifying drug craving [38]. Moreover, in the study by Heberlein A et al., (2016) [15], both testosterone and BDNF levels were found to be interrelated and significantly associated with craving intensity during alcohol withdrawal, particularly among patients with high Hypothalamic–Pituitary–Adrenal (HPA) axis activity. The correlation observed in the present study between reductions in testosterone and reductions in craving supports the idea that testosterone could act as a biological marker for craving intensity in early abstinence. As such, serial monitoring of testosterone levels could potentially be explored as a clinical tool for predicting the severity of withdrawal-associated craving and guiding pharmacological or behavioural interventions.

Limitation(s)

However, these results should be interpreted in light of several limitations. The study sample was restricted to males, limiting generalisability to female populations, in whom sex hormone interactions with craving and impulsivity may differ significantly. Furthermore, factors such as co-morbid nicotine dependence, stress levels, and medication use were not controlled for, all of which could influence testosterone levels and subjective craving. The use of purposive sampling may also introduce selection bias, and the relatively short follow-up period limits conclusions about long-term trends in testosterone and craving. Standardised alcohol-withdrawal severity scores (e.g., CIWA-Ar/TSA) were not collected prospectively and, while day 7 was chosen to minimise acute withdrawal effects, dedicated post-benzodiazepine-taper assessment was lacking; therefore, heterogeneity in withdrawal trajectories and tapering could have confounded early craving estimates, and residual confounding cannot be excluded. Despite these limitations, the study adds to a growing body of evidence suggesting a neuroendocrine basis for craving and its modulation during the course of abstinence. Further studies should explore longitudinal trajectories of testosterone and other neurohormonal markers such as cortisol, BDNF, and estradiol, while controlling for confounding variables.

CONCLUSION(S)

The present study highlights a significant association between serum testosterone levels and alcohol craving during early abstinence among male patients with alcohol dependence. While sociodemographic factors had limited influence on the severity of dependence, age and socioeconomic status were found to impact craving and impulsivity, respectively. Craving levels decreased significantly from day 1 to day 7 of abstinence, especially among those with severe dependence. A parallel decline in serum testosterone levels was observed, with a strong positive correlation between the reduction in testosterone and reduction in craving. These findings suggest a potential neuroendocrine role of testosterone in modulating alcohol craving during withdrawal.

REFERENCES

[1] World Health Organization. Global Status Report on Alcohol and Health 2018: World Health Organization; 2019.
[2] Park SH, Kim DJ. Global and regional impacts of alcohol use on public health: Emphasis on alcohol policies. Clin Mol Hepatol. 2020;26(4):652-61.
[3] Murthy RS. National Mental Health Survey of India 2015-2016. Indian J Psychiatry. 2017;59(1):21-6.
[4] Gautham MS, Gururaj G, Varghese M, Benegal V, Rao GN, Kokane A, et al. The National Mental Health Survey of India (2016): Prevalence, socio-demographic correlates and treatment gap of mental morbidity. International Journal of Social Psychiatry. 2020;66(4):361-72.
[5] Anton RF. What is craving? Models and implications for treatment. Alcohol Res Health. 1999;23(3):165-73.
[6] Flannery BA, Volpicelli JR, Pettinati HM. Psychometric properties of the Penn Alcohol Craving Scale. Alcohol Clin Exp Res. 1999;23(8):1289-95.
[7] Sinha R, Li CS. Imaging stress- and cue-induced drug and alcohol craving: association with relapse and clinical implications. Drug Alcohol Rev. 2007;26(1):25-31.

[8] Famitafreshi H, Karimian M. Hormones can influence drug addiction-A narrative review. Biomedicine (Taipei). 2021;11(2):5-10.
[9] Vermeersch H, T'Sjoen G, Kaufman JM, Vincke J. The role of testosterone in aggressive and non-aggressive risk-taking in adolescent boys. Horm Behav. 2008;53(3):463-71.
[10] Moosazadeh M, Heydari K, Rasouli K, Azari S, Afshari M, Barzegari S, et al. Association of the Effect of Alcohol Consumption on Luteinizing Hormone (LH), Follicle-Stimulating Hormone (FSH), and Testosterone Hormones in Men: A Systematic Review and Meta-Analysis. Int J Prev Med. 2024;15:75.
[11] Aubele T, Kritzer MF. Androgen influence on prefrontal dopamine systems in adult male rats: localization of cognate intracellular receptors in medial prefrontal projections to the ventral tegmental area and effects of gonadectomy and hormone replacement on glutamate-stimulated extracellular dopamine level. Cereb Cortex. 2012;22(8):1799-812.
[12] Mello NK, Mendelson JH, Bree MP, Ellingboe J, Skupny AS. Alcohol effects on luteinizing hormone and testosterone in male macaque monkeys. J Pharmacol Exp Ther. 1985;233(3):588-96. Available from https://doi.org/10.1016/S0022-3565(25)22891-9.
[13] Perry AN, Westenbroek C, Becker JB. The development of a preference for cocaine over food identifies individual rats with addiction-like behaviors. PLoS One. 2013;8(11):e79465.
[14] Emanuele MA, Emanuele NV. Alcohol's effects on male reproduction. Alcohol Health Res World. 1998;22(3):195-201.
[15] Heberlein A, Lenz B, Opfermann B, Gröschl M, Janke E, Stange K, et al. Association of testosterone and BDNF serum levels with craving during alcohol withdrawal. Alcohol. 2016;54:67-72.
[16] Stanford MS, Mathias CW, Dougherty DM, Lake SL, Anderson NE, Patton JH. Fifty years of the Barratt Impulsiveness Scale: An update and review. Personality and Individual Differences. 2009;47(5):385-95.
[17] Moeller FG, Barratt ES, Dougherty DM, Schmitz JM, Swann AC. Psychiatric aspects of impulsivity. Am J Psychiatry. 2001;158(11):1783-93.
[18] Patton JH, Stanford MS, Barratt ES. Factor structure of the Barratt impulsiveness scale. J Clin Psychol. 1995;51(6):768-74.
[19] Josephs R, Sellers J, Newman M, Mehta P. The Mismatch Effect: When Testosterone and Status Are at Odds. Journal of personality and social psychology. 2006;90:999-1013.
[20] Coates JM, Gullo MJ, Feeney GFX, Mc DYR, Dingle GA, Clark PJ, et al. Craving mediates the effect of impulsivity on lapse-risk during alcohol use disorder treatment. Addict Behav. 2020;105:106286.
[21] Heilig M, Egli M, Crabbe JC, Becker HC. Acute withdrawal, protracted abstinence and negative affect in alcoholism: are they linked? Addict Biol. 2010;15(2):169-84.
[22] Lange S, Kim KV, Lasserre AM, Orpana H, Bagge C, Roerecke M, et al. Sex-Specific Association of Alcohol Use Disorder With Suicide Mortality: A Systematic Review and Meta-Analysis. JAMA Netw Open. 2024;7(3):e241941.
[23] Kumar G, Dash P, Patnaik J, Pany G. Socioeconomic status scale-modified Kuppuswamy scale for the year 2022. International Journal of Community Dentistry. 2022;10(1):01-06.
[24] Akyel B, Aldemir E, Altıntoprak AE. [Severity of Alcohol Dependence Questionnaire: Validity and Reliability of the Turkish Version]. Turk Psikiyatri Derg. 2018;29(3):202-08.
[25] Stockwell T, Sitharthan T, McGrath D, Lang E. The measurement of alcohol dependence and impaired control in community samples. Addiction. 1994;89(2):167-74.
[26] Hartwell EE, Bujarski S, Green R, Ray LA. Convergence between the Penn Alcohol Craving Scale and diagnostic interview for the assessment of alcohol craving. Addict Behav Rep. 2019;10:100198.
[27] Beckman Coulter. Access Testosterone – Instructions for Use: Immunoassay System; Brea, CA: Beckman Coulter, Inc.; 2010.
[28] Oslin DW, Berrettini W, Kranzler HR, Pettinati H, Gelernter J, Volpicelli JR, et al. A functional polymorphism of the mu-opioid receptor gene is associated with naltrexone response in alcohol-dependent patients. Neuropsychopharmacology. 2003;28(8):1546-52.
[29] Ramirez JJ, Monti PM, Colwill RM. Brief and extended alcohol-cue-exposure effects on craving and attentional bias. Exp Clin Psychopharmacol. 2015;23(3):159-67.
[30] Kozak K, Lucatch AM, Lowe DJE, Balodis IM, MacKillop J, George TP. The neurobiology of impulsivity and substance use disorders: Implications for treatment. Ann N Y Acad Sci. 2019;1451(1):71-91.
[31] Patrick ME, Wightman P, Schoeni RF, Schulenberg JE. Socioeconomic status and substance use among young adults: a comparison across constructs and drugs. J Stud Alcohol Drugs. 2012;73(5):772-82.
[32] Koob GF, Volkow ND. Neurocircuitry of addiction. Neuropsychopharmacology. 2010;35(1):217-38.
[33] Bayard M, McIntyre J, Hill KR, Woodside J, Jr. Alcohol withdrawal syndrome. Am Fam Physician. 2004;69(6):1443-50.
[34] The ASAM Clinical Practice Guideline on Alcohol Withdrawal Management. J Addict Med. 2020;14(3S Suppl 1):01-72.
[35] Ylikahri RH, Huttunen MO, Härkönen M. Hormonal changes during alcohol intoxication and withdrawal. Pharmacol Biochem Behav. 1980;13 Suppl 1:131-7.
[36] Verdejo-García A, Lawrence AJ, Clark L. Impulsivity as a vulnerability marker for substance-use disorders: review of findings from high-risk research, problem gamblers and genetic association studies. Neurosci Biobehav Rev. 2008;32(4):777-810.
[37] Kenna GA, Swift RM, Hillemacher T, Leggio L. The relationship of appetitive, reproductive and posterior pituitary hormones to alcoholism and craving in humans. Neuropsychol Rev. 2012;22(3):211-28.
[38] Welker KM, Gruber J, Mehta PH. A Positive Affective Neuroendocrinology Approach to Reward and Behavioral Dysregulation. Front Psychiatry. 2015;6:93.

PARTICULARS OF CONTRIBUTORS:
1. Postgraduate Student, Department of Psychiatry, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam, Tamil Nadu, India.
2. Assistant Professor, Department of Psychiatry, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam, Tamil Nadu, India.
3. Professor and Head, Department of Psychiatry, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam, Tamil Nadu, India.
4. Associate Professor, Department of Psychiatry, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Kelambakkam, Tamil Nadu, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Aravindh Manogaran,
Assistant Professor, Department of Psychiatry, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, Chengalpattu District, Kelambakkam-603103, Tamil Nadu, India.
E-mail: aravindhm25@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Sep 28, 2025
- Manual Googling: Oct 28, 2025
- iThenticate Software: Nov 01, 2025 (11%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Sep 27, 2025**
Date of Peer Review: **Oct 22, 2025**
Date of Acceptance: **Nov 03, 2025**
Date of Publishing: **Feb 01, 2026**