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RESEARCH PAPER

A MODERATED MEDIATION MODEL OF AGE-RELATED DECLINE IN SELECTIVE EXECUTIVE FUNCTIONS AND QUALITY OF LIFE IN MEN WITH SUBSTANCE USE DISORDER

Shameem Fatima, Sajid Hassan, Farhat Jameel

Abstract

Objective: It is known from earlier literature that substance use is associated with diminished executive functioning and decreased quality of life (QoL). The study extended this knowledge by assessing whether selective executive function components would mediate the association between age and QoL domains in young men with substance use disorder and whether family history of substance use would moderate these mediated associations.

Method: A sample of 212 young inpatient men with substance use disorder (105 positive family history and 107 negative family history of substance use disorder) was selected from drug units/wards of government sector hospitals.

Results: The participants with positive family history compared to those with negative family history scored significantly lower on all QoL domains except physical QoL. Mediation analyses revealed that only inhibition but not flexibility mediated the negative association of age with psychological, social, and environmental QoL. Furthermore, family history of substance use moderated all the significant mediated associations with stronger indirect negative associations in participants having a family history of substance use disorder compared to those with no such history.

Conclusions: It is concluded that inhibitory control, which is vulnerable to aging, substance use, and family history of substance use, is an important factor related to QoL in young substance abuser men.

Key words: inhibition, cognitive flexibility, quality of life, family history of substance use disorder, substance use disorder

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Introduction

Substance use disorder is a pervasive public health concern affecting many people around the world. United Nations Office on Drug and Crime reports that according to world wide data for 2022, nearly 300 million people are using illicit substances (United Nations Office on Drugs and Crime, 2022). Undoubtedly, substance abuse undesirably impacts individuals' lives and societies (e.g., Daley, 2013; Schulte & Hser, 2014). Not surprisingly, executive control mechanisms are often impaired in individuals with substance abuse (e.g., Fernández-Serrano et al., 2010; Hester & Garavan, 2004; Morein-Zamir & Robbins, 2015). Likewise, dysregulation of frontal areas underlying executive control mechanisms such as the prefrontal and anterior cingulate cortex is also implicated in individuals with substance use disorder (Goldstein & Volkow, 2011; Kaufman et al., 2003). Evidence from limited functional magnetic resonance imaging studies provide underlying neural support to inhibitory behavioral deficits by showing evidence of hypoactivity in anterior cingulate cortex in cocaine and methamphetamine users compared to healthy controls (Hester & Garavan, 2004; Kaufman et al., 2003; Li et al., 2008; Morein-Zamir et al., 2013). Lining up with this, in a recent correlational study on a sample of late adolescents and young adults, executive functions (EF) are reported to be negatively associated with number of substances used and frequency of substance use (Gustavson et al., 2017).

Age-Related Weakening of EF in Individuals with Substance Use Disorder

Another noticeable feature of the evidence base is the emphasis given to declining EF abilities in aging adults. Empirical evidence supports that EF such as cognitive flexibility and inhibition show a clear age-related decline in adults (Fatima et al., 2020; Peng et al., 2017). These findings get strength from neuroimaging studies which provide structural and functional evidence

of age-related changes in brain regions associated with EF (Elderkin-Thompson et al., 2008). In typically developing Pakistani population, EF trajectory shows an inverted U shape curve with a continuous maturation up till adolescent and emerging adulthood years (Fatima & Shahid, 2020; Fatima & Sharif, 2017; Fatima et al., 2016), stability after emerging adulthood years, and a declining trend beginning from middle adulthood years in 40s (e.g., Fatima, Jamil, et al., 2019; Fatima, Khan, et al., 2020). Traditionally, studies have investigated the aging-EF link in normal aging adults, however, the link may well extend to adults with substance use disorder. It seems intuitive to discuss that the cognitive trajectory may differ in aging adults with substance use disorder who are more vulnerable to accelerated decline in EF. It is presumed that the impact of aging on EF may begin earlier in individuals with substance use disorder because substance abuse experience may drive faster the deterioration of mental health and physical capacities. A review report by Murman (2015) discusses that individuals' unhealthy life choices such as drug use as well as age related diseases can speed up the process of neuronal dysfunction, neuronal loss, and cognitive decline. Studies comparing EF ratings and EF task performance between young adults with substance abuse and healthy adults provide only indirect support for an earlier decline in EF in individuals with substance use disorder. Specifically, findings from a comparative study on young adults with substance use disorder referred to addiction treatment have reported poor performance on tasks measuring selective EF abilities including working memory, inhibition, and shifting attention compared to healthy adults in young adulthood years (Salmani et al., 2020). Findings from a similar comparative study have also revealed that adults with polysubstance abuse scored lower on ratings of all EF measures on BRIEF inventory compared to healthy control (Hagen et al., 2016). Based on these considerations, it may be presumed that age-related EF decline starts earlier in young adulthood years in individuals with substance use disorder, which is the focus of this study.

Age-Related Changes in EF and Quality of Life: Proposed Mediational Link

World Health Organization (2023) defines quality of life (QoL) as a person's perception of one's position in life within the context of culture and value systems and in connection to personal goals, expectations, and standards. Beyond reduced executive control mechanisms, individuals with substance use disorder generally report lower overall and domain specific QoL compared to general population and compared to those with other serious psychiatric disorders (Levola et al., 2020; Patra et al., 2016; Smith & Larson, 2003; Tracy et al., 2012). Beside substance use, aging is another factor which covaries with subjective evaluation of QoL. Traditionally, studies on older adult samples have reported that normal aging is associated with decreased QoL (e.g., Figueira et al., 2008). It has been argued in literature that significant life changes in relation to life course including declining physical and mental health status and changing work and financial status are associated with decreasing QoL and wellbeing (e.g., Bowling, 2005; Netuveli et al., 2006). While a recent study on a sample of young men (M age=27.73, SD=5.25) with substance use has also shown evidence of age-related decline in specific QoL domains in relatively younger years (e.g., Fatima, 2022). Building up on this line of evidence, it appears reasonable to propose that diminished QoL is featured earlier in the lives of young adults with substance use disorder because declining mental capacities including executive mechanisms (e.g., Salmani et al., 2020), physical health status, and changing work and financial status may appear earlier due to substance use coupled with aging processes (Laudet & White, 2010).

Though there is little evidence regarding the association of age-related EF decline with QoL in individuals with substance abuse, nonetheless, the evidence based on other clinical samples supports the connection of EF ratings with QoL (e.g., Stern et al., 2017). Findings from another recent study have revealed that men with substance use disorder presented weak EF leading to problems with everyday simple tasks, eventually needing assistance despite having high self-efficacy (Valdes & Lunsford, 2021). Therefore, it is reasonable to propose that decreasing QoL is associated with age-related weakening of EF in individuals with substance use disorder. Accordingly, the study formulates its first hypothesis to assess whether age-related decline in EF mediates the age-QoL link (H1).

The present study assesses two selective EF components namely inhibition and cognitive flexibility from two stand-alone tests taken from Delis-Kaplan Executive Function System (D-KEFS) test battery (Delis et al., 2001). Considering the unique feature of the battery that tests are independent of each other and investigator can use any number of these tests in any combination, the two selective tests were focused assessing two core EF functions, inhibition and cognitive flexibility. Inhibition/inhibitory control being one of the core EF describes the ability to control one's attention, behavior, thoughts, and/or emotions to override a strong internal predisposition in favor of a more appropriate or needed response (Diamond, 2013). The D-KEFS Color-Word Interference Test is the most commonly used verbally mediated measure of inhibition (Eglit et al., 2020) and is designed to be more complex and improved than the Stroop task by including an inhibition/switching trial. However, available data from clinical samples support that inhibition/switching task assessed by D-KEFS Color-Word Interference Test is not necessarily harder than inhibition only Stroop task (Lippa & Davis, 2010). Cognitive flexibility describes an individual's ability to switch between different mental sets, tasks, or strategies (Diamond, 2013; Miyake & Friedman, 2012). D-KEFS Design Fluency test is typically assumed to assess executive ability of cognitive flexibility in addition to planning and fluency in generating visual designs (Delis et al., 2001).

Family History as a Moderator

Beyond age related linear changes in EF and QoL in adults, the age-related decline in EF in men with substance use disorder may also depend on other personal and familial factors. Family history of substance use disorder can be an important factor which may likely moderate the proposed mediational age-EF-QoL link. Studies have shown that family history of substance use disorder interacts significantly with frequency of substance use (Shoal & Giancola, 2001) and substance dependence (Tapert & Brown, 2000) to predict neuropsychological functioning and EF. In light of these findings, it is presumed that family history of substance use disorder may interact with age to predict EF and to moderate the age-EF-QoL mediated link to propose that the speed of age-related changes in EF may not be similar across groups with and without family history. This may lead to a differential cognitive explanation of the age-EF-QoL

link for both groups. Therefore, the study formulates a secondary hypothesis to assess whether the meditational associations between age, EF, and QoL would differ across men with substance use disorder with and without family history of substance use (H2). Assessing these objectives on a sample of Pakistani men with substance use disorder becomes a prime concern given the data showing increasing rates of substance abuse in Pakistan (Aslam, 2019). Women were not included in the study because of limited accessibility to women with substance use disorder. Limited accessibility of the women is supported by a report from the United Nations Office on Drugs and Crime (2010) which argues that similar to many developing countries, the magnitude of substance abuse among women is masked by national denial in Pakistan. Moreover, keeping the former and latter Western research findings in sight, a dearth of indigenous literature from this region pertaining to these domains is evident and in dire need of being fulfilled.

Hence, the study will evaluate age as an independent variable, EF components as two mediators, and QoL as a criterion variable. Also, it will assess family history of substance use as a moderator of the age-EF link. Several theories including the prefrontal-executive theory (Dempster & Vegas, 1992) and inhibition deficit theory (Hasher & Zacks, 1988) imply that older adults are more susceptible to inhibitory and EF deficits because of structural and functional changes associated with aging in the prefrontal cortex. A hypothesized model has been shown in **figure 1**.

Specifically, the study formulated the following hypotheses based on the literature review.

HI: Selective EF (inhibition and cognitive flexibility) would partially mediate the negative association between age and QoL domains in men with substance use disorder.

H2: Family history of substance use would moderate the mediated associations between age, selective EF (inhibition and cognitive flexibility) and QoL domains in men with substance use disorder.

Method

Participants

The study used a cross sectional research design. Sample size was calculated using G power analysis. The calculated sample size for the independent sample t test was N= 210 (n1=n2=105, medium effect size= 0.50, power =.95, α=.05), for correlation was N= 138 (effect size= .30, power =.95, α=.05), and for regression analysis was N= 153 (medium effect size= .15, power =.95, α=.05). Accordingly, a sample of 212 (FH+=107; FH-=105) inpatient men with substance use disorder in age range from 19 to 40 years (M=27.61 & SD=5.38) was selected. The sample were selected from drug wards/ drug rehabilitation centers of government and private hospitals from Lahore, the second largest metropolitan city in Pakistan and the fifth largest city in South Asian region with more than 12 million population. Eligibility criteria included being young adults with substance use disorder, having a minimum of primary education, being able to read or understand Urdu language, and detoxified with managed withdrawal symptoms. Participants having a history of any co-morbid psychiatric diagnosis or neurological disorder, physical conditions associated with withdrawal state such as pain, or being in disoriented state were not included in the study. Such conditions were regarded in the exclusion criteria to approach a more homogenous sample as the variability due to such conditions could not be considered as an additional variable, given the already planned reasonable number of study variables. The whole sample were detoxified and under treatment in a controlled environment. Of the sample, 198 participants were using illicit drugs and the rest (n=14) were sniffing Samad bond (a licit chemical easily available in departmental stores) in addition to some illicit drug use. Regarding number and type of substances, majority of the sample were using multi-substance (n=154). The remaining participants (single substance users) were using alcohol (n=22), cannabis (n=26), heroin/opium (n=4), and cocaine (n=6). Demographic characteristics of the sample are presented in **table 1**.

Variables and Assessment Measures

Executive Functions

Two selective EF components namely inhibition and cognitive flexibility were focused in the study. The study used two performance measures namely Color Word Interference Test and Design Fluency Test taken from a test battery named Delis Kaplan Executive Functions System-DKEFS (Delis et al., 2001) to assess inhibition and cognitive flexibility (two EF). The *Color Word Interference Test* consisted of four conditions with first two conditions assessing basic cognitive functions of fundamental visual, perceptual, and linguistic abilities. Condition 1 involved naming the colors and condition 2 involved reading the color words printed in black ink.

Figure 1. *Hypothesized Moderated mediation model assessing the mediating role of executive functions in association between age and quality of life domainsand the moderating role of family history of substance use*

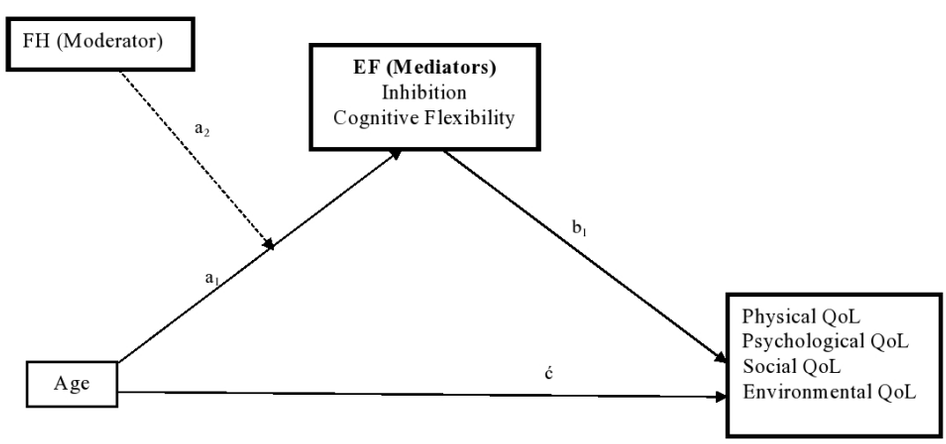


Table 1. *Demographic Characteristic of the Sample*

Variables	Full sample (N=212)	FH - (N=107)	FH+ (N=105)
	Mean(SD)	Mean(SD)	Mean(SD)
Age	27.61(5.38)	26.64(4.92)	28.59(5.76)
Education[a]	11.22(2.69)	11.71(2.68)	10.71(2.61)
Onset Age	22.29(3.58)	22.92(3.59)	21.65(3.48)
Duration of substance use	4.66(3.63)	3.66(3.59)	5.67(3.40)
Socioeconomic status[b]	Low= 103	Low=54	Low= 49
	Middle=92	Middle=44	Middle=48
	High= 17	High= 9	High= 8
Severity of substance use[c]	Low = 20	Low = 11	Low = 9
	Moderate= 133	Moderate= 69	Moderate= 64
	High = 59	High = 27	High = 32
Number of Substances used	One=58	One=31	One=27
	Multi=154	Multi=73	Multi=81

Note: FH+ = positive family history of substance use; FH- = negative family history of substance use; a = education was assessed number of years of completed education; b =self-reported socioeconomic status; c= severity index of substance use was taken from patient profile.

Last two conditions (3 & 4) assessed higher executive ability of inhibition. Third condition involved naming the ink color of the words printed with a mismatched ink color (e.g., the word "blue" was printed with green ink). Condition 4 involved switching between reading the words within the box and naming the ink color for words without box. Task completion time and number of errors on each of the four conditions were taken as two response measures of inhibition on the test. Before calculating two composite time and error scores, the individual scores were reversed. The composite score thus obtained represented higher levels of inhibition from higher composite scores. Later on, looking at the high correlation between time and error measures of inhibition ($r = .72$, $p < .001$), scores on both measures were combined to give a composite score of inhibition. Keeping in view the different score ranges on both time and error raw scores, the two scores were first standardized before calculating a composite score of inhibition.

The *Design Fluency Test* assessed cognitive flexibility in three conditions: basic, filter, and switch. Basic condition involved drawing different designs in each box by joining dots (both filled dots were presented). Filter condition involved drawing designs by joining empty dots only in (both filled and empty dots were presented). Switch condition involved drawing different designs in each box by switching between filled and empty dots. All three conditions were preceded by practice sessions. There were certain rules for drawing the designs which were required to be observed for scoring them to be correct. The response measure on this test was number of correct designs drawn within a 60 seconds time period on each of the three conditions. The composite score obtained by adding scores on 3 conditions represented a higher level of cognitive flexibility from a higher score. Considering the unavailability of norms on DKEFS tests for Pakistani participants, the raw scores on both DKEFS tests were used for data analyses.

Quality of life

The study used the Urdu version of World Health Organization Quality of Life Assessment Instrument—short version, 26 items (Khan et al., 2003) to assess QoL in four domains namely physical, psychological, social, and environmental QoL. First two items of the scale assessed general QoL and general health status; and the rest 24 items assessed four QoL domains. Responses to all items were recorded on a 5 points Likert scale. Composite scores for each of the four subscales were computed by adding the relevant items of each subscale. Higher scores on the subscales indicated greater levels of the corresponding QoL domain. The current study showed good coefficients of internal consistency for the four QoL domains (i.e., .73, .72, .70, and .71, for physical, psychological, social, and environmental QoL domains respectively).

Family History of Substance Use Disorder and Socio-demographic Covariates

Participants reported the family history of substance use disorder on a dichotomous response format of yes or no. The item, "has any of your immediate family members (parents, siblings, spouse, children) been involved in problematic substance use which require medical attention" was asked to assess the family history of substance use disorder. Participants also reported their socio-demographic information including their age (in years), education (completed education in number of year), perceived socioeconomic status (3 categories: Low, middle, or high) and ethnicity (South Asian, or others). In addition, for clinical information, they reported onset age of substance use (age in years), duration of substance use (in years), and number and type of substances used. Severity index of substance use as assessed by Addiction Severity Index (ASI) was taken from patient's profile. Though composite rating was done in 5 categories in hospital record (no problem, slight, moderate, considerable, extreme) as per ASI manual, however, considering the very small sample number in no problem category (n=2), no problem severity was merged with slight problem. Likewise, considering the very small number in extreme problem (n=3), this category was combined with considerable problem category. The resulting 3 categories were named as low, moderate and high severity.

Procedure

After obtaining approval from the Ethical Review Committee vide letter number CUI-LHR/HUM/ERC/18/049 and reviewing all the ethical considerations, the approval for data collection was obtained from the

heads of psychiatry wards and rehabilitation centers. Then, potential participants were identified with assistance of the clinical psychologists working in each selected hospital's drug unit. Next, the participants were approached and briefed about the study. After taking their consent, they were assessed on the study measures in individual setting. Order of the assessment measures was counterbalanced across participants to cancel out any effects that might likely arise from scale order. Finally, they were cordially thanked for their cooperation in the study.

Data Analyses and Results

Data set was checked and corrected for data entry errors, missing data and outliers. Missing data were less than 2% for all variables. Missing data were handled using single imputation method using series mean to replace missing values. Descriptive statistics and group differences between participants with and without family history of substance use on EF measures and QoL domains were calculated and presented in **table 2**. The results showed significant group differences on inhibition (time and error measure) and cognitive flexibility measures of EF with participants having a positive family history scoring lower on three EF scores (two inhibition scores and one cognitive flexibility score) representing poorer EF abilities compared to those with a negative family history. Furthermore, participants having a positive family history of substance use disorder scored lower on three of four QoL domains including psychological, social, and environmental as well as on general QoL and general health.

Correlations of age and both EF measures with four QoL domains as well as with general health and general QoL were calculated and presented in Table 3. Of the two selected EF scores, inhibition was positively correlated with all four QoL domains as well as with general QoL and general health indicating better inhibition ability to be associated with improved QoL and general health. Moreover, cognitive flexibility was positively correlated with psychological, social, and environmental but not with physical QoL. Also, this measure was a positive correlate of general QoL and general health.

Next, to assess the first hypothesis, multimediation models (each analyzing one QoL domain) were

Table 2. *Descriptive Statistics and Group Differences on Study Variables between men with Substance Use with a Positive or Negative Family History of Substance Use*

Variable	Full sample (N=212)			FH - (N=107)	FH+(N=105)	t value
	Mean(SD)	Alpha	Range	Mean (SD)	Mean (SD)	
Inhibition T[a]	265.11(110.71)	.93	10-397	280.72(98.48)	249.2(120.31)	2.09*
Inhibition E[a]	89.01(29.10)	.95	4-117	100.24(14.46)	77.58(35.04)	6.17***
Cognitive Flexibility	15.36(6.93)	.84	4-28	16.81(6.76)	13.89(6.82)	3.13**
Physical QOL	17.96(2.61)	.73	13-26	17.66 (2.63)	18.26(2.57)	-1.69
Psychological QOL	14.83(3.02)	.72	10-23	15.72(2.71)	13.91(3.05)	4.56***
Social QOL	7.04(2.11)	.70	4-13	7.45(2.11)	6.62(2.03)	2.92**
Environmental QOL	17.85 (4.42)	.71	12-31	19.32(4.36)	16.34(3.95)	5.17***
GQOL	1.87(.85)	-	1-4	2.07(.89)	1.66(.74)	3.68***
GH	2.28(.92)	-	1-5	2.69(.93)	1.87(.69)	7.28***

Note. *= $p < .05$, **= $p < .01$, ***= $p < .001$; T = Time score of Inhibition; E =error score of inhibition; GQOL= General quality of life; GH= General health; FH+ = positive family history of substance use; FH- = negative family history of substance use; a = time and error scores on inhibition measure are reversed

Table 3. *Correlation between Age, Inhibition, Cognitive Flexibility, and Quality of Life Domains*

Variables	5	6	7	8	9	10	11	12
1.Education	.55***	.61***	-.03	.20**	.04	.19**	.25***	.17*
2.DurationSA	-.52***	-.35***	.20**	-.16*	-.03	-.16*	-.28***	-.21**
3.Onset age	.24***	.01	.38***	.13	.05	.13	.26***	.26***
4.Age	-.58***	-.33***	-.12	-.43***	-.30**	-.23**	-.22**	-.22**
5. Inhibition[a]	-	.62***	.23**	.50***	.43***	.41***	.18*	.26***
6. Cog Flex		-	.07	.35***	.14*	.20**	.38***	.29***
7.Ph.QoL			-	.67***	.53***	.56***	.03	-.20**
8.Psy.QoL				-	.50***	.77***	.40***	.01
9.S.QoL					-	.34***	.17*	.13
10.Env.QoL						-	.16*	.03
11.GQoL							-	.15*
12.GH								-

Note=*p < .05, **=p < .01; SA=Substance Abuse; SES=Socioeconomic Status; Cog Flex=Cognitive Flexibility; Ph. QoL= Physical Quality of Life; Psy.QoL =Psychological Quality of Life; S. QoL= Social Quality of Life; Dependent=Environmental Quality of Life; Gol= General Quality of Life; GH= General Health; a = Time and error scores on

calculated by computing Model 4 in Process to assess the simultaneous mediating roles of inhibition and cognitive flexibility in association between age and QoL domains. The second hypothesis was assessed by analyzing the moderated mediation models (Model 7 in Process; Preacher & Hayes, 2008) to assess the conditional mediating roles of selected EF components (inhibition and cognitive flexibility) in relation between age and QoL domains across two groups of individuals with substance use disorder, with and without family history of substance use. Raw scores on all variables were first standardized with means = 0, and SD = 1, before analyzing the multimediation and moderated mediation models. Significant demographic factors were covaried in mediation and moderated mediation models. For each computed model, model fit index, explained variance, regression weights, Sobel z value for significance of indirect effect, and conditional indirect effects for two groups were noted. Considering that age was negatively correlated with three QoL domains (psychological, social, and environmental), multimediation and moderated mediation models were calculated only for these three QoL domains. Also, by considering the significant correlations of demographics, education and duration of substance use were taken as covariates in multimediation and moderated mediation analysis.

Findings from multimediation models showed that only inhibition out of two EF mediators significantly mediated the negative association of age with psychological, social, and environmental QoL after controlling the confounding due to potential demographics (see Model 4, **table 4**). The significant Sobel z value for inhibition as well the total, direct, and indirect effects of inhibition showed that the total effect of age on QoL domains was reduced from -.75, -.60, & -.30 to -.52, -.30, & -.27 for psychological, social, and environmental QoL domains respectively (see **figure 2**). Cognitive flexibility was initially a significant correlate of both age and the three QoL domains, however, appeared insignificant mediator in the presence of inhibition.

Finally, results from the moderated mediation models showed that family history of substance use significantly interacted with age to predict inhibition but not cognitive flexibility, hence significantly moderated the indirect effect of inhibition but not of cognitive flexibility in the mediational links of age with psychological, social, and environmental QoL domains. Further detail of moderated mediational analysis showed that conditional indirect effects of inhibition were stronger for participants with a positive family history and weaker for those with a negative family history of substance use (see Model 5, **table 4**). **figure 2** also shows that conditional indirect effects of inhibition were stronger for participants with positive family history of substance use compared to those with negative family history.

Discussion

The objectives of the study were to assess the mediating roles of selective EF components—inhibition and cognitive flexibility—in association between age and QoL domains in young men with substance use disorder and to assess whether these mediated links would be different across participants having a positive or a negative family history of substance use disorder. Both hypotheses were partially supported from the current data set as only inhibition out of two selected EF components mediated the age-specific QoL domains links and the family history of substance use disorder moderated these mediational links. Despite being the significant correlate of age and three QoL domains, cognitive flexibility did not appear as the significant mediator of the age-QoL domains links in the presence of inhibition.

Following the mediation hypothesis, age was found to be the negative correlate of inhibition and cognitive flexibility in young men with substance use disorder. Although evidence from existing literature based on the Western samples shows declining tendencies in EF in mid-twenties in typically developing young adults (Park et al., 2002), however, studies from South Asian culture report that EF remain stable during typical young adulthood years (Fatima, Jamil, et al., 2019; Fatima, Khan, et al., 2020). Contrarily, the present study based on data from the same South Asian cultural context shows declining tendencies in EF in young adulthood years in individuals with substance use disorder despite the evidence of stability of EF till mid 40s in the same cultural context in normal adults (Fatima et al., 2020). The finding may be justified in that continuous substance use may correlate with earlier age-related decline in EF in young adulthood years in individuals with substance use disorder. Therefore, young individuals with substance use disorder may have presented slower speed on cognitive tasks, took more processing time, and made more errors. Also, it is quite possible that changes in basic cognitive resources (visual, perceptual, and linguistic abilities) associated with substance use may underline the poor functioning on selective EF components. The finding is noteworthy in another way, that is, age is strongly correlated with inhibition indicating that inhibitory control component of EF compared to cognitive flexibility is more vulnerable to aging in men with substance use disorder. Similar to the present study findings, Brockett et al. (2018) discuss in their review that EF deficits become more pronounced with increased duration and dependency on substance use. Importantly, age remained a significant correlate of inhibition and cognitive flexibility even after controlling the duration of substance use for the present sample.

Pertaining to aging-QoL link, though evidence from healthy samples shows decreasing QoL in aging older adults (e.g., Figueira et al., 2008) but the finding from the current study sample of young men with substance use disorder have revealed an earlier age-related decline in QoL during young adulthood years. This finding lines up with study's proposition and with rarely available data (e.g., Fatima, 2022). Third, the current finding is different from the prevailing evidence based on studies conducted on typically developing adults which describe young adulthood years to be very productive (Campos et al., 2014). This difference may be attributed to substance abuse.

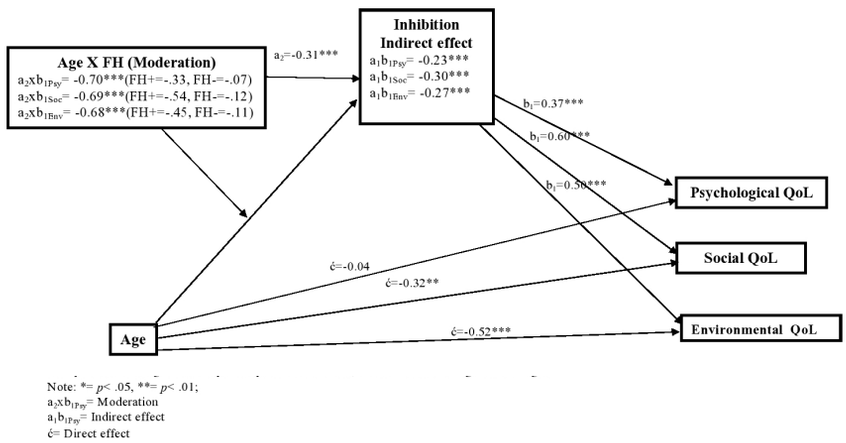
Pertaining to mediation hypothesis, it was found that inhibition was a strong mediator of the association of age with three QoL domains namely psychological, social, and environmental QoL in the current study sample. The results line up with the previous literature based on other clinical samples showing a link between EF ratings and QoL (Stern et al., 2017). Although the earlier findings were not exactly in line with our mediational hypothesis and population of interest, the current study provides initial evidence that inhibition is a predictor of all QoL domains as well as a mediator of age-QoL link in an Asian sample of young men with substance use disorder. Currently, on one hand, the literature is available on the age-EF link on different

Table 4. *Moderated Mediation Models Representing Conditional Indirect Associations between Age, Inhibition, and QOL Domains*

Predictors	Outcome Variables								
	Model 4	Model 7		Model 4	Model 7		Model 4	Model 7	
	Psy.QoL[a]	Inhibition[b]	Cog.Flex.[b]	Social QoL[a]	Inhibition[b]	Cog.Flex.[b]	Env.QoL[a]	Inhibition[b]	Cog.Flex.[b]
Education	.03(.03)	.16(.02)***	.23(.02)***	-.03(.03)	.16(.02)***	.24(.02)***	.01(.03)	.15(.02)***	.25(.02)***
Duration SA	.13(.02)***	.04(.02)	.07(.02)**	.12(.02)***	.04(.02)*	.06(.02)*	.03(.03)	.04(.02)*	.06(.02)**
Age	-.52(.10)***	-.19(.07)*	-.50(.10)***	-.32(.10)**	-.20(.07)**	-.48(.10)***	-.04(.11)	-.21(.08)**	-.48(.10)***
Inhibition	.37(.09)***	-	-	.60(.09)***	-	-	.50(.10)***	-	-
cognitive flexibility	.04(.08)	-	-	-.14(.08)	-	-	-.12(.09)	-	-
FH[c]	-	-.31(.08)***	-.13(.10)	-	-.30(.08)***	-.16(.10)	-	-.29(.08)***	-.15(.10)
Age X FH	-	-.70(.08)***	.20(10)	-	-.69(.08)***	.20(10)	-	-.68(.08)***	.18(10)
R^2	.37	.70	.48	.32	.69	.46	.18	.69	.48
Model fit	(5,204)23.65***	(5,206)90.59***	(5,206)37.08***	(5,206)19.26***	(5,206)90.53***	(5,206)35.61***	(5,204)8.78***	(5,206)89.77***	(5,206)37.03***
Total effect	-.75(.09)			-.62(.09)			-.30(.10)		
Direct effect	-.52(.10)			-.32(.10)			-.04(.11)		
Indirect effect	-.23(.06)			-.30(.06)			-.27(.08)		
Indirect effect (inhibition)	-.21(.06), Sobel z = -3.72***			-.35(.06), Sobel z =-5.21***			-.31(.09), Sobel z =-4.22***		
Indirect effect (cog. Flex.)	-.02(.03), Sobel z = -0.54			.05(.03), Sobel z = 1.59			.04(.03), Sobel z = 1.18		
Conditional Indirect effect (inhibition)	FH+ = -.33(.09)			FH+ = -.54(.08)			FH+ = -.45(.11)		
	FH-= -.07(.03)			FH-= -.12(.05)			FH-= -.11(.05)		
Conditional Indirect effect (cog. Flex.)	FH+= -.01(.02)			FH+= .04(.03)			FH+= .03(.03)		
	FH- = -.02(.04)			FH- = .07(.04)			FH- = .06(.05)		

Note. *= $p < .05$, **= $p < .01$; *** = $p < .001$: FH = Family History of Substance Use; Psy.Qol =Psychological Quality of Life; Cog.Flex. = Cognitive Flexibility; FH+ = positive family history of substance use; FH- = negative family history of substance use; a = Dependent variables; b = Mediator; C = moderator; Values in parentheses are SE; Model 4 = Mediation model calculated in Process; Model 7 = Moderated mediation model calculated in Process

Figure 2. *Moderated mediation showing indirect associations between age, inhibition, and QoL domains partecipants with positive and negative family history of substance use. Values shown are regression weights*



samples and particularly on normal aging adults (Fatima et al., 2020); and on the other hand, literature is also available for the EF-QoL link on clinical samples but earlier studies have not focused to examine meditational associations between age, EF, and QoL domains in healthy or clinical samples. Importantly, the current study has assessed this objective on a sample of young men with substance use disorder from a different cultural context, a patriarchic culture from a South Asian region. Notably, lining up with the existing literature on EF ratings and task performance (Fatima et al., 2020; Stern et al., 2017), cognitive flexibility was a correlate of age and three QoL domains, however, appeared an insignificant meditator in the presence of inhibition which appeared as a more powerful mediator.

The mediational links were significant for specific QoL domains including psychological, social, and environmental QoL. The findings are worth discussing in several ways. First, with increasing age, continuing substance use may hamper their psychological and social QoL by weakening their psychological resistance and social bonds given the evidence for social support as a positive correlate of QoL in adult clinical population (Fatima & Jibeen, 2019). Also, financial burden of substance use may hamper their environmental QoL. Mainly, the present study used a sample of men only from a patriarchal culture; it is quite possible that aging would have differential or weak mediational links for women with substance abuse from the same culture, where financial burden is the sole responsibility of men. However, women were not included in the study considering the gender wise non proportionality of the data. Obtaining proportionate number of women with substance use was seemingly impossible because of gender stereotypical societal attitudes, underrepresented magnitude of substance uses by women masked by national denial, and eventual limited accessibility to women with substance abuse. Of note, inhibition but not cognitive flexibility appeared as significant in relation to physical QoL. Though both of the earlier constructs are components of EF, yet showed differential links with physical QoL. It seems intuitive to argue that strong inhibition ability may serve the function of inhibiting the individuals from unhealthy life choices and habits in favor of healthy ones predicting good physical QoL. While cognitive flexibility in terms of shifting focus between alternate or multiple choices may not be directly relevant in this regard.

A secondary hypothesis was examined to assess the moderating role of family history of substance use disorder on the mediational associations between age, selective EF components, and QoL domains. From the moderated mediation analyses, it was found that inhibition more strongly explained the negative link of age with psychological, social, and environmental QoL in men with substance use disorder having a positive compared to those having a negative family history of substance use disorder. A likely justification is that inhibition scores were significantly different between men with substance use disorder having a positive compared to those having a negative family history. The individuals with substance use disorder with a positive family history clearly presented poorer scores. Although the age-related decline in EF may occur in response to substance use in young men, it is possible that this declining tendency becomes more apparent in individuals with substance use disorder with a positive family history, which may have led to different mediational explanations of the age-QoL link across two studied groups. The findings from Shoal and Giancola (2001) supported the same that the high-risk group of adolescent boys with a positive family history scored lower on EF tasks compared to the low-risk group with a negative family history and that the family history moderated the negative correlation between frequency of substance use and EF. This empirical evidence can be regarded as a remote support for the present study because the direct supporting evidence for the conditional mediated associations across groups with a positive versus negative family history of substance use is not present in the previous literature.

Limitations, implications, and future directions

This is a cross sectional quantitative study which has provided preliminary evidence of age-related weakening of selective EF abilities and decreasing QoL starting from young adulthood years in a sample of young men with substance use disorder from a patriarchal culture in South Asian region, yet direction of associations cannot be determined. Moreover, the role of different types of substances in EF or QoL could not be assessed or compared because of disproportionate sample in different substance categories. Future studies are recommended to compare participants with different categories of substance use in terms of EF or QoL. In addition, the study collected self-report data from the participants only, hence, common method bias may have caused overestimation of the observed associations. However,

several methodological remedies such as use of different assessment methods including performance based and self-report assessment measures, counterbalancing the order of assessment measures across participants, and protecting the participants' anonymity were used to control common method bias in the study. Yet the findings provide an initial clue that the studied population becomes vulnerable to declining status of mental capacities and decreasing QoL in younger years due to substance use, and requires health and support services.

The empirical information on these factors, which are supplementary determinants of effective intervention, may guide intervention planners towards improved treatment planning and clinical practice. Understanding how deficits in executive control mechanisms are originated at a younger age and contribute to diminished QoL by the cycle of substance abuse is paramount to plan better intervention strategies, tailor treatment options, and opt psychological services for younger men with substance use disorder. The increasing age as a determinant of inhibitory capacities and QoL of individuals with substance use disorder may highlight that services should be customized to meet their changing executive cognitive needs and reduce their increasing vulnerability. The findings also offer an avenue to provide EF training to these individuals which in turn would have better implications for their QoL.

The study is significant in that it has evaluated the role of aging in association with cognitive and functional limitations, which is an emerging area of investigation for developmental researchers. Assessing these objectives on the samples with substance use disorder becomes imperative given the evidence that an increasing number of individuals with substance use disorder are surviving into older age (Gossop & Moos, 2008). However, the generalizability of the finding would be limited to only population of men with substance use disorder living in the studied region. Also, the study had a relatively small sample of men, and did not include women and middle-aged and older men. The vulnerability of later groups to aging and substance abuse may vary due to different needs, responsibilities, experiences, and access to treatment services. The study provides avenues to future researchers to conduct longitudinal studies with larger and variant ageing cohorts of individuals with substance use disorder representative of gender and social status variations from wider geographical regions to be confident on the causal associations between age related decline in EF and QoL.

Conclusion

To conclude, findings from the study revealed that inhibition strongly mediated the negative age-QoL link among men with substance use disorder with a positive compared to negative family history of substance use. Thus, the findings highlight the importance of introducing EF training particularly incorporating elements of inhibitory control for better implications for improved QoL in men with substance use disorder. In the long run, preventing substance abuse on a large scale seems essential to decrease the negative consequences of family history of substance use on EF development in descendants, which in turn would lead better QoL outcomes.

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