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RESEARCH ARTICLE

Assessment of stress and cognition among adolescent males and females

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ABSTRACT

Background: The psychophysiological changes that people experience due to long-term cognitive activity is stress. Compared to adults, adolescents are more prone to stress due to change in the level of stress hormones. Stress has an impact on cognitive parameters. Stress and cognition can be modulated by the sex steroids. Hence, this study was done to know the gender difference in perceived stress and its effect on cognition among adolescents. **Aims and Objectives:** The aim of the study was to record and compare stress and cognition among male and female volunteers. **Materials and Methods:** After getting Institutional Ethical Committee clearance, informed written consent was obtained from all the participants. 30 male and 30 female volunteers were selected by simple random sampling method after applying inclusion and exclusion criteria. Stress was recorded using perceived stress scale, cognitive tests such as digit symbol substitution test (DSST), letter digit substitution test (LDST), mini-mental status examination (MMSE), Wechsler memory scale (WMS) revised-spatial addition subtest, design subtest, simple visual reaction time (SRT), choice visual reaction time (CRT), and critical flicker fusion frequency (CFFF) were recorded among male and female volunteers in the Department of Physiology, Sri Venkateshwaraa Medical College Hospital and Research center, Ariyur, Pondicherry. **Results:** Perceived stress scale is significantly decreased in females ($P = 0.0046$). Cognitive parameters such as LDST ($P < 0.0001$), WMS design ($P = 0.0016$), and MMSE ($P = 0.0003$) significantly increased among the females with less stress but DSST ($P < 0.0001$) significantly increased among the males. SRT, CRT, CFFF, and WMS spatial did not show any significant difference between both the genders. **Conclusion:** Thus, from this study, we conclude that stress is significantly decreased among females than males which might be due to the reason that all the recordings in the female were recorded during the menstrual phase where all the female sex hormones are in the basal level. Certain cognitive parameters were significantly increased in females with less stress and some in males with more stress; thus, stress has a varied effect on cognition in males and females.

KEY WORDS: Adolescents; Critical Flicker Fusion Frequency; Cognition; Stress; Visual Reaction Time

INTRODUCTION

Mental stress refers to psychophysiological changes that people experience due to long-term cognitive activity that requires sustained mental efficiency.[1] Most of the stressors are intellectual, emotional and perceptual for human. Adolescents are more sensitive to stress. This might be due to an increase in the level and sensitivity of stress hormone such as glucocorticoids in response to aversive physical and psychological stimuli in adolescents compared to adults. Adolescent mammals were found to be more sensitive to the environment which might bring changes in physiology, behavior, and cognition that persists into adulthood.[2] Important developmental changes in the biological systems controlling reproduction, cognition, and ability to respond to adversity typically occurs during adolescence.[3]

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Exposure to stress during adolescence was found to shape adult cognition. Stress during adolescence was found to have a beneficial effect on some learning and memory process and detrimental effects on other. Mild acute stress can cause rapid and dramatic loss of prefrontal cognitive abilities.[4] Although number of studies were done on effect of exam stress and its effect on reaction time (cognitive indicator) among male and female medical students, none were done to know the difference in the level of perceived stress and cognition among the adolescents using number of cognitive parameters in addition to reaction time in south India; hence, this study was chosen to determine the gender difference in stress and cognition among the adolescents. The main objective of our study is to determine and compare perceived stress score, a battery of cognition function tests, critical flicker fusion frequency (CFFF), simple reaction time (SRT), and choice reaction time (CRT) among the female volunteers and male volunteers.

MATERIALS AND METHODS

This observational study was conducted in the Department of Physiology, Sri Venkateshwaraa Medical College Hospital and Research Center, Ariyur, Pondicherry. 60 healthy volunteers within the campus of age between 18 and 25 years with normal body mass index (18–24.99 kg/m^2) were selected randomly.[5] Among them, 30 were female and 30 were male. All the participants have completed the high school education. Subjects with a history of color blindness and regular practice of Yoga/exercise, females with irregular menstrual history were excluded.

After getting Institutional Ethical Committee clearance, informed consent was obtained from all the participants. Perceived stress score was assessed using the perceived stress scale (PSS). The following tests were used to measure the cognitive function. All the parameters were recorded in the morning between 10 am and 12 pm in the Department of Physiology. All the recordings were done during the menstrual phase (day 1–3) calculated from LMP- last menstrual period for the female subjects.[5]

Digit Symbol Substitution Test (DSST)

The test was done to assess the neuropsychological activity of the brain. It consists of (e.g., symbol pair 1/-, 7/^) one digit and one symbol in pairs followed by a list of digits. Under each digit, the subject should write down corresponding symbol as fast as possible within 90 secs. The number of correct symbols within the time allowed was measured, and scores were awarded.[6]

Letter Digit Substitution Tests (LDST)

The test sheet was given the key gives the number 1–9, each paired with the different letter; the test items are printed beneath the key. Subjects was asked to replace the randomized letters with appropriate digit indicated by the key. The first 10 items were used as practice items, for example, digit pairs (w/1,b/2,t/3…….j/9) followed by list of alphabets. Under each alphabet, the subject must be instructed to write down the corresponding digit within 60 secs of the time period. The number of correct response was considered as a score.[6]

Mini Mental Status Examination (MMSE)

It was be done by asking a set of 11 questions under the following section such as orientation, registration, attention, calculation, recall, and language. The questions are very basic such as name of the year, season, month, and date the total score was assessed. The maximum score was 30. The score ≤23 is considered as cognitive impairment.[6]

Wechsler Memory Scale-revised (WMS-R)

It includes two types of tests.

Spatial Addition Sub Test

It assesses visuospatial storage and manipulation in working memory. The subjects were shown 4 × 4 grid with blue and red dots on it for 5 secs. They were asked to remember the location of the blue dots and ignore the location of red dots on that page. On the second page red and blue dots were shown again for 5 secs; the subjects have to add the two visual images together. The subjects are given 4 × 4 puzzle grid and red, blue, and yellow cards. The subject must place the blue dot in the grid in a location where they see blue dots on either page and yellow dot where blue dot appear in common.[6]

Design Sub Test

The subjects were shown a page with designs placed in the grid. They have 4, 6, 6, and 8 designs to remember. The subject was asked to remember the design and its location. After seeing the stimulus page for 10 secs, the subject was given puzzle grid and cards with designs on them. The subject must select the cards with correct designs and place them in puzzle grid in the correct position. After 20–30 min of delay, the subject was given the cards to place in the grid again. Following the delay recall task, delayed recognition scores were calculated.[6]

Reaction Time

RT measurement includes the latency in the sensory neural code traversing the peripheral and central pathways along with perceptive, cognitive, and volitional processing.[7] In simple reaction time, there is only one stimulus and one response. 'X at a known location, the subject has to press the button once the X is seen by him on the screen. In choice

reaction time, the user must give a response that corresponds to the stimulus, such as pressing a key corresponding to a letter if the letter appears on the screen using Deary-Liewald Reaction time tester.[8]

CFFF

CFFF is measured with a portable device which has an in-house built LED. Monochromatic red LED light of wavelength 630 nm, fixed on white background is used as flickering light source. Frequency adjustment is done by software-based variable frequency square wave oscillator (10–50 Hz). Frequency measured from the recorded data using Audacity software. Tests were done in a minimally illuminated room, with the CFFF measuring device kept at a distance of 30 cm. Instructions were given, and the subjects were asked to respond by lifting the hand and were tested for increasing and decreasing frequencies. At one point, the flickering light stops and light is perceived as a steady source if the frequency is increased from lower to higher. At one point flickering appears when the frequency is decreased from higher levels. Both ascending and descending frequencies were recorded, and the mean of the two is taken as CFFF.[9]

Statistical Analysis

All the data are expressed as mean±SD. Independent student's *t*-test[10] was used to compare all the parameters between male and female volunteers using GraphPad Prism software.

RESULTS

Table 1 show that PSS is significantly decreased in females. SRT and CFFF did not show any statistical significance between the groups. CRT shows faster response in females with less stress without any statistical significance. Table 2 shows that cognitive parameters such as LDST, WMS design, and MMSE significantly increased among females with less stress, but DSST significantly increased among males. WMS - spatial addition subtest did not show any statistical significance between males and females.

DISCUSSION

Table 1 shows that in our study perceived stress was significantly decreased ($P = 0.0046$*) in females compared to males. SRT ($P = 0.9985$) and CFFF ($P = 0.7592$) did not show any statistical difference between males and females. CRT was less among the females as they react fast to the stimulus but insignificant ($P = 0.1136$). Table 2 shows that among all the battery of cognitive tests parameters, the tests such as MMSE, LDST, and WMS-Design were significantly increased ($P < 0.005$) among the females. DSST was significantly increased ($P < 0.0001$) among the males compared to females.

Table 1: Comparison of percieved stress, reaction time, CFFF among males and females

Parameters	Males	Females	*P* value
PSS	22.50±3.627	19.80±3.458	0.0046*
SRT (ms)	321.5±48.72	321.4±54.70	0.9985
CRT (ms)	565±123.4	514.8±118.5	0.1136
CFFF (Hz)	31.37±4.359	31.14±2.529	0.7592

*$P<0.05$ - statistically significant. PSS: Perceived stress scale, SRT: Simple reaction time, CRT: Choice reaction time, CFFF: Critical flicker fusion frequency

Table 2: Comparison of cognitive tests among males and females

Parameters	Males	Females	*P* value
LDST	35.70±5.646	43.23±5.697	<0.0001*
WMS design	1.867±1.907	3.300±1.418	0.0016*
WMS spatial	3.300±1.418	3.267±1.388	0.927
MMSE	25.43±2.515	27.67±1.900	0.0003*
DSST	60.10±9.707	24.60±3.410	<0.0001*

*$P<0.05$ - statistically significant. LDST: Letter digit substitution test, WMS design: Wechsler memory scale design subtest, WMS spatial: Wechsler memory scale spatial subtest, MMSE: Mini-mental status examination, DSST: Digit symbol substitution test

In contrast to our study Charney *et al*. and Handa *et al*. reported that testosterone in males lower the ACTH and glucocorticoid level in both basal and reactive conditions, therefore, males are less stressed.[11,12] Reaction time, being the index of cognitive performance showed the difference in the latency between male and female medical students.[4] Similarly, our results showed a slight difference in choice reaction time. Further, Singhal *et al*. proposed an increase in the reaction time on exposure to stress.[13] Thus, in our study also males with more stress have increased in the reaction time indicating stress delays the processing of neural information. Ginsburg *et al*. did not find a significant difference in CFFF between males and females, similarly in our study there is no gender difference in CFFF, but Ali *et al*. have shown that CFFF decreases with increase in stress.[14,15] Our results on cognitive tests such as MMSE, LDST, and WMS-Design were decreased among the males with more stress similar to the study done by Wang *et al*. who found that stress could decline the cognitive ability due to impairment in synaptic plasticity.[16]

However, DSST is significantly increased among males with more stress compared to females. This is similar to the results of Chaby *et al*. who got positive response on learning and memory with an increase in stress during adolescent period.[3]

Decrease in stress in females might be due to complete decrease in the level of estrogen and progesterone during menstrual phase of the normal menstrual cycle. Literature suggests that low dose of estrogen suppress the HPA axis

and thereby decreases the cortisol and high dose increase the hormonal stress response.[11] Reaction time, a sensitive index of sensory-motor coordination is expressed in milliseconds.[7] Hence, the ability to process information, faster judgment, and the ability to concentrate and coordinate were found to be better among females with less stress compared to males. This was further supported by findings of Singhal *et al*. where reaction got prolonged on exposure to acute stress like cold pressor due to the release of epinephrine and nor-epinephrine.[13] CFFF is an accepted indicator of cortical arousal level. It is being used as an indicator of human fatigue, mental workload, and cognitive function.[9] Animal studies showed that female rats were more sensitive to stress-induced cognitive decline than male rats. Thus, estrogen might amplify the prefrontal cortex (PFC) response to stress.[17] This is contradictory to our results where the stress show a significant raise in males and the cognition is more affected in males compared to females. Men display high cortisol level on exposure to acute stress hence decrease in cognition compared to females.[18] McCormick *et al*. have shown that exposure of adolescents to stress have lasting effects on cognitive physiology that persists into adulthood. He also added that hippocampus is the vulnerable region to stress and stress decreases neurogenesis.[17] Arnsten *et al*. showed that acute mild stress impaired the accuracy of response due to PFC dysfunction due to activation of the hypothalamus and brain stem which evokes a high level of dopamine and nor-epinephrine and CAMP signaling.[4] Stressed adolescent rats were found to exhibit enhanced learning and memory. Adolescent stress had a positive impact on behavioral flexibility in adulthood. Thus, stress was found to have a beneficial effect on some part of cognitive parameters and detrimental effect on others.[3]

Neuroimaging studies showed that there is gender specific neural activation due to stress. Males show flight and fight response in response in response to PFC activation to stress, whereas females show limbic activation and stimulate the reward system.[19] Hence, the gender difference in cortisol reactivity to stress and its effect on cognition might be due to difference in the level of sex steroids among the male and female adolescents. The main limitation of our study is that we are not able to measure the hormonal level of cortisol and sex steroids due to financial constraint.

CONCLUSION

From this study, we conclude that stress is significantly decreased among females than males which might be due to the reason that all the recordings in the female were recorded during the menstrual phase where all the female sex hormones are in the basal level. Certain cognitive parameters were significantly increased in females with less stress and some in males with more stress; thus, stress has a varied effect on cognition in males and females.

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