

Relationship between Cognitive Flexibility, Subjective Vitality and Levels of Physical Activity among Undergraduate Students Attending Online Classes

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ABSTRACT

Background: In response to the global COVID-19 pandemic, the bulk of learning was conducted online. Cognitive flexibility (CF), subjective vitality (SV), and physical activity are necessary for producing alternate solutions to challenging situations, for having the energy and enthusiasm to perform better and enjoy life. This study explored the relationship between CF, SV, and levels of physical activity among undergraduates, which is essential to assess student performance better and execute online learning. **Method:** 260 undergraduate students attending online classes between the age of 18 to 24 were recruited for the study. Google forms which consisted of CFI, SVS and IPAQ-SF7 were used to collect data. Kruskal-Wallis test and regression analysis were used to analyse the information obtained. **Results:** There was no significant relationship between CF, SV and levels of physical activity. It was found that CF predicts SV. CF and SV did not differ significantly among undergraduates attending online classes for different amounts of time. **Conclusion:** The study indicated that CF could predict SV among undergraduates. To effectively manage online learning and provide students with techniques for strengthening their adaptative capacities, factors contributing to CF must be assessed and explored.

Keywords: *Online Classes, Cognitive Flexibility, Subjective Vitality, Levels of Physical Activity, Undergraduate Students*

The evolution of our specific biological life history is linked to adaptation to new environments. It is a remarkably complicated interplay of various factors, including distinct human cognitive and cultural innovations. Around the world, the juncture from the year 2020 is remembered as a period of transformation when unparalleled flexibility and vitality was needed. In response to the global COVID-19 pandemic, the bulk of learning was conducted online and the sector of online education has grown significantly in India. A great deal of cognitive and behavioral flexibility was required to make creative adaptations in order to cope with an unexpected, rapidly evolving, and demanding situation. There is a global spike in research on various elements of online education including the disadvantages

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like distraction and reduced focus, heavy workloads, technological and internet issues, and a lack of adequate support from teachers and peers (Hussein et al., 2020). For emerging adults, transitioning to university or under graduation is a stage during which they shift to a new developmental phase (Benn et al., 2005); undergraduates are regarded to be especially vulnerable throughout the transition to college (Montgomery & Cot 'e, 2008) and face the developmental difficulty of shifting to maturity, with the highest incidence of mental health disorders happening well before 24 years of age (Kessler et al., 2007).

Cognitive flexibility (CF) is “an individual’s (i) awareness that in any given situation there are options and alternatives available (ii) willingness to be flexible and adapt to the situation, and (iii) self-efficacy in being flexible” (Martin & Rubin, 1995). It can also be described as the predisposition to recognise when changing one's perspective or behaviour is necessary, to alter one's course of action in response, and to assess the success of the adjustment (Spiro et al, 2007). In this research, CF is defined as the ability to understand difficult situations as manageable, to discern multiple different interpretations for life events and human behaviours, as well as the generation of various viable approaches to difficult problems.

CF is a distinguishing element of human cognition. According to developmental and lifespan studies, flexibility appears to encourage academic achievement, employment success, stable transitioning to adulthood, coping with stress and other positive life outcomes. Students with high CF have self-knowledge which help them accomplish clear goals by modifying the information they obtain in view of their previous encounters. They will quickly adjust to newer circumstances, deal with stress, and solve problems (Anderson, 2002; Bertiz & Kocaman Karoğlu, 2020). They were also good at finding information online, interacting with peers and teachers online, and tracking their progress (Schommer-Aikins & Easter, 2018). They have incentives and options to determine the trajectory of their behaviours in most situations; as a result, they may adjust better to changed or new work demands and conditions, and may be happier, indicative of a better sense of vitality (Demirtas, 2020). Computerized cognitive training, physical exercise, and advanced curricula have all been suggested as possible approaches to help children become more flexible, but the evidence for their effectiveness is mixed (Uddin, 2021) and there is little research indicative of such interventions among young adults.

Furthermore, the pandemic is marked by a significant downturn of individuals' psychological well-being. Happiness, purpose, and vitality are three facets of psychological well-being. Frederick and Ryan (1997) introduced the idea of *subjective vitality* (SV), which was described as an individual with lots of energy, enthusiasm, vividness, and vigour (Ryan & Frederick, 1997). A lively and joyful individual is attentive and fresh, as well as full of life and energy (Ryan & Deci, 2002). This study defines SV as the energy and enthusiasm for performing better and enjoyment in life.

A sense of vitality is regarded as an essential predictor of happiness. SV is linked to psychological factors like autonomy and connectedness, as well as physical health and is regarded as the pinnacle of physical and mental well-being. Previous experience is related to new information through CF, and an individual's level of liveliness can be assessed at various levels by using vitality measures. Developing, enhancing, and maintaining SV is a critical and significant factor, especially among students, since it plays an important role in achievement and life satisfaction. When vitality is poor, irritability and fatigue are generated, and capacity to do activities is not adequately addressed whereas when it is at a higher level,

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enough energy is produced to carry out certain tasks, and have a positive mood, all responsibilities and operations are completed to a high standard (Ryan & Deci, 2001).

SV can be a useful predictor of personal well-being because of its positive correlation with biological and psychological factors (Bostic et al., 2000). SV is correlated with specific brain regions and emotional responses, therefore those who are highly vitalized are more active and effective, which aids in coping with stress and overcoming challenges (Barrett et al., 2004). Pupil with higher degrees of vitality use a range of learning techniques that improve their chances of academic excellence (Lepper, 1988). Students with high SV are more inclined to partake in healthy learning activities, such as doing their assignments on time, than students with low SV (Mouratidis et al., 2017). Ryan and Fredrick (1997) discovered that not only does SV have a link to psychological qualities like autonomy and relatedness, but it also has a link to physical health (Ryan & Frederick, 1997). Learners who believe their requirements are met in the institute gain from institutional adjustments and have increased academic motivation and self-control in academic matters. SV and problem-solving abilities are related, and as problem-solving abilities become more effective and efficient, so will SV (Bostic et al., 2000).

Physical activity is any physiological motion that uses skeletal muscles and needs energy expenditure. Occupational, sports, conditioning, domestic, and other activities can all be classified as physical activity in daily life. Peluso and Andrade (2005) suggests that the benefits of physical activity on mental health have been explained by a variety of psychological hypotheses, the most common of which are 1) distraction, 2) self-efficacy, and 3) social contact. The distraction hypothesis proposes that diverting attention away from unpleasant stimuli improves mood during and after physical activity. The self-efficacy hypothesis states that, because physical activity might be perceived as a difficult task, the ability to engage in it on a regular basis can enhance mood as well as self-confidence. According to the social interaction hypothesis, the connectedness that seem to be frequent in physical activity, as well as the supportiveness that happens among people who exercise, play a key part in the mental health benefits of physical activity (Peluso & Andrade, 2005). Physical activity enhances executive functions, according to an increasing number of studies (Li et al., 2017; Xue et al., 2019). It has a significant impact on student involvement in the classroom and attention (Owen et al., 2016). CF is improved by long-term physical activity interventions among young population (Haverkamp et al., 2020; de Greeff, 2018). SV may be a factor for explaining why physical activity improves academic performance. Quick bursts of intense physical activity boost students' SV and on-task performance (Mavilidi et al., 2020). Acute physical activity before tasks requiring high levels of cognitive inhibition could improve adolescent's vitality and cognitive function (Pastor et al., 2020).

There is a significant lacuna in research about these variables and their interactions, especially among Indian students. As online education has become a necessity, understanding the relationship between these variables in the context of India has dire implications for developing and implementing programmes that provide both personal and social support in effectively managing online learning, and could be a potential contributor to effective pedagogy. The information gathered on the population's flexibility and vitality, particularly during pandemic conditions, will contribute to the literature and overall understanding of the population's characteristics as well as experience, with a focus on young adults. In this study, the question asked is 'what is the relationship between CF, SV and levels of physical activity among undergraduate students attending online classes?' and 'can CF possibly predict SV

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among undergraduates?’ The aim is to study the relationship between CF, SV, and levels of physical activity among undergraduate students attending online classes.

METHODOLOGY

The study has a cross sectional design where participants were measured on 3 scales i.e., Cognitive Flexibility Inventory (CFI, 2010), Subjective vitality scale (1997), International Physical Activity Questionnaire Short Form 7 (IPAQ-SF7).

Objectives

Primary objective is to examine the relationship between CF, SV and levels of physical activity among UG students attending online classes. The secondary objectives are to explore if CF predicts SV and to examine the relation between CF, SV and average time spent in online classes.

Hypotheses

1. There is a significant relationship between CF, SV and levels of physical activity among UG students attending online classes
2. CF predicts SV.
3. CF, SV and average time spent in online classes are related.

Participants

Participants, males and females, currently pursuing their under graduation in online mode were selected for the study. The inclusion criteria are given below:

1. UG students of any stream aged 18 to 24
2. Attending online classes for at least 2hrs daily
3. Studying in India

Sampling method

The data was collected using the Snowball sampling approach and in an online mode (Google forms).

Sample size

Estimation of sample size was done using the formula:

$$n = \frac{(Z_{1-\alpha/2} + Z_{1-\beta})^2}{\left(\frac{1}{2} \log\left(\frac{r+1}{1-r}\right)\right)^2}$$

where,

$Z_{1-\alpha/2} = 1.96$, at level of significance (α) = 0.05

$Z_{1-\beta} = 0.84$ at 80% power

With anticipated correlation, $r = 0.2$.

The estimated sample size was a minimum of 191 undergraduate students.

Study setting

The study was based in Manipal Academy of Higher Education, conducted with participants from all over India, using Google forms (online mode) during the period from April 2021 to June 2022.

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Measures

- **Personal data sheet:** It was used to gather the relevant demographic variables such as age, gender, course, institution, and daily average time spent in online class.
- **Cognitive Flexibility Inventory (CFI):** CF was measured using the CFI comprising of 20 items (10 items each on alternative and control subscale). Each item was rated on a 7-point Likert scale, with 1 being strongly disagree and 7 being strongly agree. The scoring was carried out by adding the scores for the items for alternative scale (items 1, 3, 5-6, 8, 10, 12-13, 14,16,18-20) and the control scale (2, 4, 7, 9, 11, 15 & 17) with reverse score items 2, 4, 7, 9, 11, & 17 to obtain a single dimensional score of CF. The scale was used to compute a single-dimensional score for CF. High scores indicate high CF. It had a high internal consistency, convergent validity and test-retest reliability, α score between 0.90- 0.91, $r = 0.81$.
- **Subjective vitality scale (SVS):** This scale was used to assess people's energy and enthusiasm for performing better and enjoyment in life. It consisted of 7 items (e.g., "I nearly always feel awake and alert") on a 7-point scale with 1 implying not true at all to 7 indicating very true. The overall score varies from 7 to 49. A higher score suggests more SV. The initial form's internal consistency coefficient was 0.84, and its reliability (Cronbach's alpha) was 0.94.
- **International Physical Activity Questionnaire Short Form 7 (IPAQ-SF7):** The total physical activity was found in METs using IPAQ-SF7 which included 7 open-ended questions about an individual's last seven days of physical activity (self-reported). The METs calculation was done as follows:
 - *Walking METs minutes/week = 3.3 X walking minutes X walking days*
 - *Moderate METs minutes/week = 4.0 X moderate intensity activity minutes X moderate days*
 - *Vigorous METs minutes/week = 8.0 X vigorous intensity activity minutes X vigorous-intensity days*
 - *Total MET-min/week = (Walk METs*min*days) + (Mod METs*min*days) + (Vigorous METs*min*days)*

Categorical Score- 3 levels of physical activity as per IPAQ-SF7 are:

1. *Low*
 - *No activity is reported OR*
 - *Some activity is reported but not enough to meet Categories 2 or 3.*
2. *Moderate - Any one of the following 3 criteria*
 - *3 or more days of vigorous activity of at least 20 minutes per day OR*
 - *5 or more days of moderate-intensity activity or walking of at least 30 minutes per day OR*
 - *5 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 600 MET-min/week.*
3. *High - Any one of the following 2 criteria*
 - *Vigorous-intensity activity on at least 3 days and accumulating at least 1500 MET minutes/week OR*
 - *7 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 3000 MET-minutes/week"*

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Based on METs, the participants were categorised into 3 levels of physical activity: high, moderate, and low. Test-retest reliability show acceptable stability and reliability is high with $\alpha < 0.80$.

Procedure

Clearance from Department of clinical psychology, Institutional Research committee (IRC), and Institutional Ethics committee were obtained to conduct the study. After protocol received IEC clearance, required documents were submitted to CTRI and data collection started. Initial participants who met the inclusion requirements were selected through personal and professional interactions. Individuals who agreed to take part in the study were sent the link to Google forms which consisted of Informed consent, Personal data sheet, Cognitive flexibility inventory, Subjective vitality inventory and International physical activity questionnaire-SF. Initial recruits were requested to pass on the details of others who met the criteria for inclusion and these potential participants were approached in the same manner. Reminder mail was sent to the participants who fail to respond within a period of 2 weeks. The link to Google form was deactivated after the data collection period. The responses of participants were stored in a cloud database, and the results were automatically filtered, scaled and ranked in a personalised excel sheet. Data collected from the participants was then used for statistical analysis.

Data analysis

SPSS was used to record the data collected in the study. Normality of data was tested by Kolmogorov-Smirnov test. To study the relationship between CF, SV and levels of physical activity among undergraduate students attending online classes, Kruskal-Wallis test was used. Regression analysis was used to explore if CF predicts SV.

Ethical considerations

Informed consent was taken before the initiation of data and all participation was voluntary. The sharing of any information was strictly restricted to the researcher and the ethics committee involved in ensuring that all the procedures were followed properly. Limited interaction with the participant was ensured and demographic data only necessary for the study was recorded to ensure that limited personal data was collected and stored.

RESULTS AND DISCUSSION

Results

A total of 260 undergraduate students with a mean age of 19.892 and SD of 1.707, participated in the study. The sample included 140 females and 120 males. Students recruited were from a wide range of undergraduate programmes with the maximum number of study participants from BSc degree (33.1%) followed by BTech (19.6), MBBS (15%) and BA (7.3%). The study also recruited participants from BPharm, BCA, BCom, BBA, LLB, BDS, diploma, BArch, Bed, BPES, and BTHM. 28% of the participants attended online classes for 2-3 hours, 25% for 3-4 hours and 47% for more than 4 hours. 36.92% of the participants were active at low levels, 37.30% at moderate and 25.77% at high levels.

The descriptive statistics for the CFI and SVS were calculated. The CF and SV scores had means of 89.07 and 33.60, and SD of 11.20 and 6.59 respectively, which ranged in moderate levels respectively.

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1. Relationship between CF, SV and levels of physical activity

Table 1 *Kruskal-Wallis test examining relationship between CF, SV and levels of physical activity among undergraduate students attending online classes*

Variable	Df	Chi square statistic (H)	p-value
CF	2	2.4633	0.2918
SV	2	1.293	0.524

Table 1 shows the Kruskal-Wallis test used to examine the relationship between CF, SV and physical activity levels among undergraduate students taking online classes who were physically active at low, moderate, and high levels. There was no significant difference in CF and SV at the $p < 0.05$ level for the three levels of physical activity [$H(2) = 2.4633, p = 0.2918$; $H(2) = 1.293, p = 0.524$]. These results suggested that both CF and SV did not differ significantly among undergraduate students with low, high and moderate levels of physical activity.

2. Relationship between CF and SV

Table 2.1 *Spearman's Correlation between CF and SV (N=260)*

Variable		Subjective vitality
CF	Spearman's rho	.300*
	Sig. (2-tailed)	< 0.001
	N	260

Correlation is significant at the 0.01 level(2-tailed).

Table 2.1 demonstrates that Spearman's correlation was used to determine the correlation between CF and SV. There was a modest significant positive relation between CF and SV ($r_s = 0.300, p < 0.001$), implying that as CF increases, SV also increases or vice versa.

Table 2.2 *Ordinal regression analysis indicating the effect of CF on SV (N=260)*

Model Fitting Information				
Model	-2 Log Likelihood	Chi-Square	Df	Sig.
Intercept Only	1087.432			
Final	1069.486	17.946	1	<.001*
Goodness-of-Fit				
		Chi-Square	Df	Sig.
Pearson		1685.118	1673	.413
Deviance		775.721	1673	1.000
Pseudo R-Square				
Cox and Snell	.276			
Nagelkerke	.277			
McFadden	.051			

As shown in Table 2.2, ordinal regression was used to test if CF predicts SV among undergraduate students attending online classes. CF accounted for a significant amount of variance in SV, likelihood ratio, $\chi^2(1) = 17.946, p < 0.001$. The Pearson chi-square test [$\chi^2(1673) = 1685.118, p = 0.413$] and the deviance test [$\chi^2(1673) = 775.721, p = 1.00$] suggested a good model fit. The model accounted for approximately 5.1% of the variance in the outcome, McFadden's pseudo- $R^2 = 0.051$.

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It was seen that almost all thresholds were statistically significant at a significance level of 0.05. The logged odds represent that CF was statistically significant, $p < 0.001$ and carry a positive coefficient ($df=1$, estimate= 0.043, SE= 0.010) according to Wald test. Hence it was concluded that CF can significantly predict SV among undergraduate students attending online classes.

3. Relationship between CF, SV and online class hours

Table 3 Kruskal-Wallis test examining relationship between CF, SV and online class hours

Variable	Df	Chi square statistic (H)	p-value
CF	2	2.676 ^a	.262
SV	2	2.766 ^a	.251

As indicated in Table 3 there was no significant difference in CF and SV at the $p < 0.05$ level for the different amount of time spent in online class [$H(2) = 2.676$, $p = 0.262$; $H(2) = 2.766$, $p = 0.251$]. These results suggested that both CF and SV did not differ significantly among undergraduate students attending online classes for 2-3 hrs, 3-4hrs and more than 4hrs daily.

DISCUSSION

The study aimed to explore the relationship between CF, SV, and levels of physical activity among undergraduates in the context of online classes. It was found that there is no statistically significant relationship between CF, SV, and levels of physical activity. Additionally, it was found that the amount of time spent in online classes had no noticeable relation with CF and SV, and CF predicts SV.

The findings of the present study contradict with the findings of numerous studies and meta-analyses that evaluated the influence of different physical activity programs on CF, which indicated a relation between CF and physical activity (Haverkamp et al., 2020; D. Yadav, 2019; J. Hwang et al., 2016). There are also a few studies that found no significant relationship between CF and physical activity (Eg: Van der Niet et al., 2015). Several studies have demonstrated that physical activity, notably mindful exercise programmes boost vitality (Ginoux et al., 2021; Marenus et al., 2021; Dagar et al., 2020; Molina-Garca et al., 2011).

How do we explain our findings? The deviation between current and previous findings that explored the relation between CF and levels of physical activity may be due to the low amount of both attention allotment and cognitive effort in daily physical activity of students attending online classes throughout the past two years of the pandemic.

The types and levels of physical activity and sitting time that participants engaged in daily over the course of the previous seven days were examined in this study. The scores were used to classify them into 3 levels: high, moderate, and low, with majority of participants falling under low or moderate categories. The nature of physical activity and the attention allocation factor according to it were not considered. It is still unclear whether habitual physical activity, which is a person's usual daily activity pattern, including sedentary behaviour, is linked to CF. Intense physical activity increases neurotransmitters, which is assumed to raise an individual's physiological arousal level, which in turn improves cognitive performance by increasing attention allocation as proposed by the psycho-physiological hypothesis (de Greeff et al., 2017). There are arguments that a cognitively difficult aerobic physical activity, rather than a 'simple' aerobic physical activity, is better for cognition. Physical activities that require a higher level of cognitive involvement are thought to have a greater impact on executive

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functions than those that need a lower level of cognitive engagement and include more mechanical movements. The various underlying processes indicate that the impact of physical activity on CF may vary depending on the duration or kind of physical activity (aerobic versus cognitively engaged). The degree of cognitive involvement varies by task and by age, suggesting that the relative contribution of physical activity to the development of executive functioning may fluctuate over time.

To establish what types of interventions will result in SV, the determinants of energetic activation must be established. The type of physical activity has a major influence on the individual's vitality as well. Sonnentag et al.'s (2017) postulations, which suggest that the activities people engage in and the involvement they have during their recreational time are linked to their vitality and overall well-being (Sonnentag et al., 2017), could be a plausible explanation for the findings.

A notable outcome of the study was that CF and SV had a weak positive relationship and that CF can predict subjective vitality. One of the most important factors affecting one's perception of vitality is CF. There are close connections between educational experiences, CF, and SV, according to studies (Algharaibeh, 2020; Muhammad Abd al-Bar Azhar, 2020). This conclusion is consistent with the previously obtained research findings and is attributable to the fact that individuals with higher CF can readily adjust their cognitive structure, which aids them in effectively solving issues. Individuals feel attentive, prepared, and upbeat when they believe they can handle a variety of challenges. They are able to deal with a variety of situations because of their awareness, effectiveness, and abundance of energy and activity. It reflects on their sense of competence, making them feel self-vital.

Limitations of the study

During the data collecting period, some participants attended both online and offline classes, which is likely to have influenced the variables under investigation. This has posed a major limitation to the study. The type of physical activity the participants performed were not considered. The sample included undergraduate students from a wide range of courses that were not evenly represented in the sample. The sample size was small. The study relied on self-report questionnaires, thus concerns about desirable responses and reliability of responses could be questioned.

Strengths and implications of the study

This study was able to investigate these variables in the context of India. There is a significant gap in research on the topic of CF and SV, this study focused on that. The study sample was centred on undergraduates in the context of online learning; these variables have not been studied extensively in this group. Males and females were evenly distributed among the participants in the study.

The study helped develop a better understanding of CF and SV among students. This will aid universities in developing various programmes that offer personal and social assistance in efficiently managing online learning as well as equip them with strategies for improving their adaptative abilities. Levels of CF prevalent in college students was detected. This data can be used to develop early cognitive training strategies that can enhance CF in young adults which helps to reduce the impact of its deterioration with age. Assessments of SV highlights the scope for building programs that enhance vitality as well as overall well-being among college students. The data acquired on the population's flexibility, vitality, and activity levels

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particularly during pandemic conditions, add to the literature and overall understanding of the population's traits and experiences, with a focus on young adults.

Future directions

A larger sample size can be used to help predict the generalizability of the results. In order to gain a better grip on the relation between CF, SV, and levels of physical activity, the undergraduate students' cognitive involvement and experiences with physical activity should be investigated. Physical activity levels before and after the outbreak of the pandemic can be compared to see if there are any significant alterations, as well as its impact on CF and SV. The mediating role of demographic variables such as age, gender and course of study can be studied along with CF and SV in order to further develop an understanding about the impact of these variables.

CONCLUSION

The study found that both CF and SV did not differ significantly among undergraduate students with high, low and moderate physical activity levels, as well as for different amounts of time spent in online classes. CF predicts SV among undergraduate students attending online classes. Overall, to effectively manage online learning and provide students with techniques for strengthening their adaptative capacities, factors contributing to CF must be assessed and explored, which will in turn contribute to their overall well-being.

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Conflict of Interest

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