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Original Research Article

Effect of prenap coffee on daytime sleepiness in university students

Dishant B. Upadhyay*, Siddharth B. Agrawal, Anita Verma, Neeraj Mahajan, Nilima Shah

Department of of Physiology, Smt. NHL Municipal Medical College, Ahmedabad, Gujarat, India

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***Correspondence:**
Dishant B. Upadhyay,
E-mail: dishantu1998@gmail.com

ABSTRACT

Background: Daytime sleepiness impairs academic performance in college students. Napping is a counter to daytime sleepiness, but often causes sleep inertia on waking up. Caffeine absorption from beverages peaks 30 minutes after their ingestion presenting a window of opportunity to have a short nap such that the time of waking up is in synchrony with onset of action of caffeine; thereby abolishing post-nap inertia and achieving synergistic mitigation of fatigue. Objective of this study to assess effect of nap, coffee, 'coffee and nap' and 'wakeful break without coffee' on daytime sleepiness using Psychomotor Vigilance Tests (PVTs) and Karolinska Sleepiness Scale (KSS) score.

Methods: After Institutional Review Board clearance, 10 subjects (aged 19-21 years) were selected using their Epworth Sleepiness Scale score (ESS >5) and called to the study site 8 times on different days to be exposed to these four conditions twice - only coffee (standardized), only nap (30min), coffee immediately followed by 30min nap, wakeful break (30min) without coffee or nap. Pre and post scores were recorded for electronic PVT (Reaction Time and Motor Responsiveness) and KSS for each attempt.

Results: Test outcome was associated with intervention used (p=0.00001). 'Nap only' group was associated with deterioration in outcomes (p=0.00001), accounting for highest percentage (41%) of all deteriorated test outcomes. 'Coffee only' group was associated with improvement in test scores (p=0.00001), responsible for highest share (38.8%) of all improved test outcomes. 'Nap only' and 'Coffee-nap' group showed improvement in 11.67% and 21.67% of outcomes respectively.

Conclusions: Pre-nap coffee is a proactive counter-measure to post nap sleep inertia.

Keywords: Daytime sleepiness, Prenap coffee, Sleep inertia

INTRODUCTION

Daytime sleepiness is the subjective feeling of fatigue and lethargy during the wakeful hours of the day. College students have been found to be especially at risk for experiencing daytime sleepiness.[1,2] In the setting of the rigorous undergraduate medical course where academic challenges and poor sleep hygiene abound, it emerges as a leading cause of impaired academics with over 27.5% of MBBS students reportedly suffering from Excessive Daytime Sleepiness (EDS).[3] Napping is a viable and effective way to mitigate daytime sleepiness and 73% of college students engage in it.[4] However, upon waking up from a nap subjects often experience a period of "sleep inertia" i.e. a period of mental fatigue and impaired alertness that arises due to awakening from deep sleep.[5,6] Unhealthy napping habits have the potential to adversely impact nocturnal sleep, and are associated with poor sleep hygiene.[7]

Thus taking up measures to counteract the sleep inertia that follows afternoon naps increase the viability of napping as a counter to daytime sleepiness. Studies have confirmed that shorter naps are more efficacious and are associated with reduced sleep inertia.[6,8] Caffeine enhances systemic adrenergic activity and stimulates the

Central Nervous System by blocking the A1 and A2 Adenosine receptors, thus it reduces mental fatigue and improves alertness.[9] Caffeine is among the most widely used psychoactive stimulant in the world. It is present in a large number of products of daily consumption like tea, coffee, soft drink beverages, chocolate etc., with over 77% of Indian college students regularly consuming caffeine in the form of tea or coffee.[10-11]

According to pharmacokinetic studies, caffeine absorption from ingested coffee peaks 30-120 minutes after its ingestion.[12] Hence, the interval of 30 minutes post ingestion of coffee can be used as a window of opportunity to have a short nap, such that, time to wake up is in synchrony with onset of action of caffeine. Thus, a synergistic mitigation of fatigue and sleep inertia can be achieved. Pre-nap caffeine has been found to reduce post nap sleep inertia significantly.[13,14]

According this review of literature, prior studies have documented the efficacy of these “coffee naps” in drivers, and industrial workers but none so far have been conducted for testing their efficacy in alleviation of daytime sleepiness in students.[6,13]

With this background, the objective of this study was to assess effect of ‘nap’, ‘coffee’, ‘coffee and nap’ and ‘wakeful break without coffee’ on daytime sleepiness using Psychomotor Vigilance Tests (PVTs) and Karolinska Sleepiness Scale (KSS) score.

METHODS

In a longitudinal design, this study extended from March 2018-April 2018. Target population consisted of undergraduate medical students. For subject selection authors conducted a survey among 412 students using Epworth Sleepiness Scale (ESS-1997). Those willing to give informed consent and having ESS score ≥5 were included. Those taking any medication, having active illness or with incomplete forms were excluded.[15]

Authors thus selected 12 subjects. Upon enrolment, authors familiarised them to the procedure of alertness tests to be used during the study and recorded their chronotype, baseline caffeine consumption and total weekly sleep using standardized questionnaires.[10,16,17]

Over the next 6 weeks, subjects underwent following controlled conditions twice - “Only Coffee” (75mg caffeine in 200ml cup), “Only Nap” (30min shut eye rest), “Coffee with Nap (30min)” and “No-Intervention”, during which they had 30min wakeful break and weren’t allowed to eat, drink, or engage in physical activity.

Sessions were scheduled between 3pm-4pm. Upon arrival, subjects deposited their cellular phones; after which three pre-exposure tests were conducted and scores noted. They were then exposed to the respective experimental condition, immediately after which, tests were repeated. Authors used 3 tools to measure alertness - Karolinska Sleepiness Scale (KSS), to score subjective sleepiness; Electronic Reaction Time, an objective marker, and electronic Dottime Score, to measure motor skills. Thereafter, difference between pre and post exposure test scores (delta value) was computed.[18-20]

Data analysis

Shapiro-Wilk test was conducted and upon obtaining $p < 0.05$ for all scores, authors used non-parametric tests. Kruskal Wallis test was used to assess the distribution of scores and post-hoc analysis was done using Mann-Whitney tests, p values so obtained were adjusted using Bonferroni correction. Wilcoxon’s test was done to assess difference in alertness scores for first and second attempt per subject. Delta values were condensed into outcomes, and Chi-Square test was then used for qualitative analysis.

RESULTS

From the subject pool of 12 subjects, authors lost 2 subjects to attrition during the course of the 6-week study. For the resultant pool of N=10 subjects, 4 were males and 6 were females. Mean age of subject pool was 19.7 (± S.D. 0.95) years.

Mean ESS score was 11.2 (±S.D. 4.94) and 6 subjects suffered from Excessive Daytime Sleepiness (EDS) while 4 had Normal Daytime Sleepiness (NDS). The mean MEQ score was 47.9 (±S.D.=7.53) and 9 subjects belonged to Intermediate Chronotype while 1 subject belonged to Evening Chronotype.

As interpreted from the NSF sleep diary, the subjects reportedly spent an average of 49.5 (±S.D. 9.99) nocturnal hours in bed for the week before the study began. Six subjects spent more than 50 nocturnal hours weekly in bed while 4 subjects spent less than 50 nocturnal hours weekly in bed. CCQ scores showed a mean consumption of 12 (±S.D=7.43) serves of caffeinated items per week. Two subjects consumed less than seven servings of caffeinated items per week, 5 subjects consumed 8-14 serves of caffeinated items per week and 3 subjects consumed more than 14 serves of caffeinated items per week.

Results of qualitative analysis

Test outcome was associated with intervention used (χ^2 =60.362, dF=6, p=0.00001) but not with age (p=0.323), sex (p=0.214), Hours of nocturnal time in bed per week (TIB) (p=0.795), number of serves of caffeinated items per week (p=0.25), EDS prevalence (p=0.59) or chronotype (Fischer’s Exact test p=0.918).

As seen from the results (Table 1), ‘Coffee-Nap’ group was significantly associated with improved outcomes (χ^2 =6.613; p=0.01), while ‘Nap only’ group was associated with 'deterioration' in test outcome (χ^2=9.825; p=0.002). Test-wise distribution of outcomes across groups (Table 2) shows the highest share of deteriorated outcomes for all tests was in the Nap-Only group. Combined, both groups that involved napping accounted for 75% of all deteriorated outcomes. During the course of the study, subjects were asked to nap for total of 40 sessions (Twenty for 'Nap only' and 20 for 'Coffee with Nap'), out of which they self-reported falling asleep for a total of 31 sessions.

No significant difference was found in the number of subjects self-reporting falling asleep (p=0.451) between the two groups involving napping.

Table 1: Distribution of test outcomes across the four groups for N=60 outcomes per group.

Group	Share of Improved Outcomes	Share of Deteriorated Outcomes	No Change in Test Score
No Intervention	53.33%	26.67%	20.00%
Only Coffee	55.00%	20.00%	25.00%
Only Nap	11.67%	78.33%	10.00%
Coffee with Nap	21.67%	65.00%	13.33%

Table 2: Distribution of Outcomes for alertness tests across the groups for N=20 outcomes per test per group.

Test	Group	Improved Outcomes	Deteriorated Outcomes	No Change in score
KSS	1. No Intervention	50.00%	20.00%	30.00%
	2. Only Coffee	45.00%	5.00%	50.00%
	3. Only Nap	5.00%	90.00%	5.00%
	4. Coffee with Nap	5.00%	75.00%	20.00%
Reaction time	1. No Intervention	55.00%	45.00%	0.00%
	2. Only Coffee	70.00%	30.00%	0.00%
	3. Only Nap	10.00%	90.00%	0.00%
	4.Coffee with Nap	30.00%	70.00%	0.00%
Dottime Score	1. No Intervention	55.00%	15.00%	30.00%
	2. Only Coffee	50.00%	25.00%	25.00%
	3. Only Nap	20.00%	55.00%	25.00%
	4. Coffee with Nap	30.00%	50.00%	20.00%

Results of quantitative analysis

Pre-exposure test scores were not differently distributed across the four 4 groups (Table 3), while the delta values for the scores for all tests were significantly different in distribution across the four groups. No significant difference was found in the percent change of all alertness test scores between first and second attempt for all subjects for all interventional groups (p=0.520).

Pair-wise post hoc analysis yielded 7 significant associations (Table 4), whose comparison was done using their respective mean ranks (Table 5).

For KSS and Reaction time, reduction in scores and mean rank denotes an improvement in alertness, while the reverse is true for Dottime Score. Thus, groups "No-intervention" and "Coffee-Only" had significantly improved scores as compared to the groups "Nap-Only" and "Coffee with Nap" (Table 5). However, as per the post-hoc analysis scores were not found to be significantly different between the two groups constituting these 2 pairs.

Table 3: Results of Kruskal Wallis test to check for difference in distribution of scores across the four groups.

Score	p value
Pre-exposure KSS	0.49 (N.S*.)
Pre-exposure Reaction Time	0.754 (N.S.)
Pre-exposure Dottime	0.537 (N.S.)
Delta value KSS	0.0001 (S#.)
Delta value Reaction time	0.0001 (S.)
Delta value Dottime	0.029 (S.)

* Non-significant # significant

No statistically significant difference was found in the magnitude of change in alertness test scores across the groups 'Nap-only' (group 3) and 'Coffee with Nap' (group 4).

Table 4: Mean ranks for delta values of the four interventions for groups for the three tests.

Group Number	Group	Test	Mean Rank
1	No intervention	KSS	24.95
2	Coffee Only	KSS	22.85
3	Nap Only	KSS	61.58
4	Coffee with Nap	KSS	52.62
1	No intervention	Dottime Score	50.88
2	Coffee Only	Dottime Score	44.18
3	Nap Only	Dottime Score	30.52
4	Coffee with Nap	Dottime Score	36.42
1	No intervention	Reaction Time	36.65
2	Coffee Only	Reaction Time	25.25
3	Nap Only	Reaction Time	56.35
4	Coffee with Nap	Reaction Time	43.75

Table 5: Results of pair wise Mann Whitney tests, significant associations are compared using their mean ranks.

Test	Group-wise Comparative Improvement in Alertness	Adjusted p value
KSS	2>3	0.0001
KSS	2>4	0.0001
KSS	1>3	0.0001
KSS	1>4	0.001
Dottime Score	1>3	0.03
Reaction Time	2>3	0.0001
Reaction Time	1>3	0.044

In order to document the interventions responsible for best improvement in alertness test score; maximally improved score per test was tabulated against the respective interventional group for every subject (Table 6). For KSS, 2 subjects performed equally best in 2 or more interventions. For Dottime score and Reaction Time, best score was achieved only in one intervention per subject. No subject gave his/her best performance in the nap only group. No subject gave his/her best performance of all three tests concurrently in any one interventional group.

For each of the three tests, the pair of scores obtained in the first and second attempt per subject per interventional group were not found to be significantly different (Wilcoxon's Signed Rank Test p=0.520).

The percentage change in KSS scores was found to be significantly correlated with percentage change in Reaction Time (Spearman's Rho p=0.001 r =+0.361) and percentage change in Dottime score (Spearman's Rho p=0.023, r=-0.254) however percent change in reaction time was not significantly correlated with percent change in Dottime score (p=0.07, r= -0.203).

Table 6: Group-wise distribution of number of subjects showing maximum improvement in scores.

	Number of subjects per group			
Test	No-intervention	Only coffee	Only nap	Coffee with Nap
KSS	6	4	0	2
Reaction time	4	4	0	4
Dottime	6	2	0	2

DISCUSSION

Test outcomes were not associated with age, sex, chronotype, ESS score, baseline weekly time in bed or baseline weekly caffeine consumption of the subjects. This can be attributed to the homogeneity of the sample that was studied. Test outcome was significantly associated with intervention used.

The two groups which did not involve napping accounted for 77% of all improved outcomes. The two groups which involved napping accounted for three-fourths of all deteriorated outcomes (Table 1).

Nap-Only group had highest share of deterioration in outcomes and least number of improved outcomes (Table 2). The effect of sleep inertia induced by napping can thus be demonstrated. Despite the short of duration of time allowed in bed, effects of sleep inertia were felt probably due to selection of subjects having higher daytime sleepiness as scored by the ESS, and prevalence of poor sleep hygiene and evening chronotype in the subjects.[21]

"Coffee Only" group had highest number of improved outcomes and least number of deteriorated outcomes (Table 2). This is due to the psycho-stimulant action of caffeine present in coffee and the absence of napping and associated sleep inertia in this group.

In terms of number of improved and deteriorated outcomes, 'No-Intervention' group was only marginally inferior as compared to coffee only group. Here, subjects took a wakeful break without caffeine for a period of 30min and resorted to activities like talking, listening to music, using their smart phones etc. Improvement in alertness in this group is partly a circadian phenomenon, since there occurs a progressive increase in alertness as the body moves away from the period of post lunch dip. This finding also highlights the possible role of socialisation and leisure activities in improving daytime alertness.[22,23] Additionally, dose of caffeine in 'Coffee-Only' Group may not have been high enough to cause significant increase in alertness as compared to non-interventional group. Nevertheless, non-interventional dissipation of daytime sleepiness merits further investigation.

'Coffee with Nap' group was associated with significantly higher number of improvement in outcomes as compared to nap only group. Thus Pre-nap coffee appeared to have reduced sleep inertia on waking up. However, this group was inferior as compared to the Coffee-Only and Non-interventional group, which may be attributed to high degree of sleep inertia induced by napping in the subjects.

Pre-exposure alertness test scores were not significantly different across the four groups (Table 3). Also, the percentage change in all alertness test scores was non-significantly different for first and second attempt for all subjects for all interventional groups. This reflects the homogeneity of experimental conditions that were provided during the course of the study. The magnitude of change in post-exposure alertness test scores was significantly different across the four experimental groups (Table 3). Pair-wise post hoc analysis revealed that this delta value in alertness test scores was significantly different for the two pairs of groups, namely those not involving nap and the two groups involving nap, but not among the groups within the pair (Table 5).

No significant difference in delta value was found between the 'Nap-Only' and 'Coffee with Nap' groups. While the 'Coffee with Nap' group had higher number of improved outcomes in alertness tests, the magnitude of change in test scores was not significant as compared to nap only group. The results of this study differ from previous studies that have documented the clear superiority of 'Coffee with Nap' over 'Nap only' group and 'Coffee Only' group.[6,13] This can be attributed to many factors, namely- longitudinal design of this study that might enhance the impact of accumulated sleep debt on daytime nap architecture, selection of subjects having higher daytime sleepiness, restorative nap habits rather than appetitive or mindful napping in the students and lower dose of caffeine used as compared to previous studies. These factors combined likely induced a degree of sleep inertia that the dose of caffeine authors used was able to only partly ameliorate.[7,24]

Change in subjective sleepiness levels as denoted by the percent change in KSS scores correlated significantly to the percent change in objective alertness tests namely the reaction time and the Dottime score. However, the percent changes in scores of objective alertness were not significantly correlated to each other. Hence authors suggest that parameters of subjective sleepiness levels should be the target of interventions aimed at increasing daytime alertness in student population.

This study was not without limitations. Authors could control only the time in bed but had no objective parameter to mark sleep onset or duration of sleep. The composition of lunch consumed by subjects was not accounted for and this could have had an impact on gastric emptying time and absorption of caffeine. Subjective variations in mood that could impact the psychomotor vigilance tests and recall bias at the time of selection by questionnaire cannot be ruled out.[25]

CONCLUSION

In the subjects studied, daytime napping induced a sleep inertia that led to lethargy on waking up. Pre-nap coffee was found to be a proactive counter measure to post-nap sleep inertia. In terms of number of outcomes improved, "Coffee-Only" group emerged as the best counter to daytime sleepiness. Non-interventional dissipation of daytime sleepiness in late afternoon period was significant and requires further analysis.

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