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The impact of sleep quality, meal timing, and frequency on diet quality among remote learning university students during the COVID-19 pandemic

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ABSTRACT

Our objective is to assess the relationship between meal timing, frequency, sleep quality, and diet quality (DQ) among university students engaged in remote learning during the COVID-19 pandemic. To achieve this, a cross-sectional study was conducted in April 2021. We employed a self-administered electronic questionnaire to gather data. Participants self-reported their anthropometric and sociodemographic information. Physical activity (PA) levels were evaluated using the International PA Questionnaire (IPAQ), while sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI). DQ was determined using a short-form Food Frequency Questionnaire (FFQ), and the data were stratified into quartiles. A total of 311 students completed the questionnaire. Half of the participants (53.2%) exhibited a moderate DQ. Interestingly, female participants had a higher proportion of individuals with high DQ (22.5%) compared to males (9.8%). Conversely, males had a higher percentage of participants with moderate DQ (68.9%) compared to females (49.4%) (P=0.016). Participants with high DQ reported significantly more consistent meal timing, such as fixed meal times, waking up early, going to bed early, feeling hungry during breakfast and lunchtime, and having breakfast in the morning (P<0.001). Participants with low DQ reported moderate to low levels of PA and poor sleep quality (P<0.001). Our findings are consistent with relevant studies conducted in different regions of the world. In conclusion, remote learning during the COVID-19 pandemic has been associated with adverse changes in meal timing and frequency, as well as compromised sleep quality. Furthermore, it has been linked to a prevalence of moderate DQ among university students.

1. Introduction

The worldwide COVID-19 pandemic has already caused a sizeable public health problem resulting from the introduction of strict social lockdown and self-quarantine measures that limited the spread of the virus (WHO, 2020) Consequently, telecommunication was promoted, and schools and universities were closed (Al Hourani et al., 2022) The COVID-19 crisis and lockdown actions were likely to have had considerable social consequences and contributed to changes in weight-related behaviors, involving physical activity (PA) levels and dietary habits of individuals (Brooks et al., 2020; Shevlin et al., 2020; Pearl, 2020). Throughout the pandemic, food supply chain interruption and panic purchasing may have also limited individuals' access to fresh foods and increased their dependency on unhealthy foods with extended shelf lives (Tan et al., 2020). Similarly, people may have been reluctant to exercise in public facilities because of fear of contracting the virus. According to Garg et al. (2020) study, obese adults reported that their protective attitude against weight gain had declined as compared to before the COVID-19 lockdown.

Studies also indicated that the timing of food intake may affect a person's circadian rhythms in metabolic organs, a current risk factor associated with metabolic diseases and obesity (Melkani and Panda, 2017; St-Onge et al., 2017). Many factors have

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been proposed to affect weight such as environmental changes, eating patterns (Kant and Graubard, 2015), meal timing and frequency, as well as cardiometabolic health in people (Paoli et al., 2019; Gallant et al., 2014). As meal timing is connected with meal frequency and other dietary behaviors, such as late eating, more comprehensive evidence on the associations of meal timing and frequency with metabolic disease is needed. Moreover, high internet usage, which in turn has led to increased screen timing and decreased sleeping hours, has been associated with negative health outcomes (Kim et al., 2018, 2019).

Diet Quality Scores (DQS) have been created to evaluate dietary patterns, which describe the complexity of food intakes rather than the individual food item and the usual consumption of foods in typical diets (Satija et al., 2017; Willett and Stampfer, 2013). Most of the studies that estimated the impact of the COVID-19 pandemic on populations' nutritional status and diet quality (DQ) were based on macro or micro-level simulations (Picchioni et al., 2022). Several studies found a greater association between DQ and socioeconomic deprivation in COVID-19, suggesting a direct vital role of low DQ on COVID-19 responsiveness and progression (Merino et al., 2021; Kim et al., 2021). On the other hand, the lockdown period was associated with a decrease in the DQ, which could be partly explained by changes in food choice motives and weight-related behaviors (Marty et al., 2021; Robinson et al., 2021). Therefore, this study aimed to examine the impact of meal timing, frequency, regularity, food consumption patterns, and sleeping quality on DQ among remote-learning university students during the COVID-19 pandemic.

2. Materials and methodology

2.1. Study design and ethical approval

This was a cross-sectional study, which was completed using a self-reported online survey via the Google Forms web survey platform. Participants were recruited through the official networks of Al-Balqa Applied University, Al-salt, Jordan. All participants were informed about the study objectives at the beginning of the questionnaire, then they expressed their informed consent to participate, and their data were anonymous. The study was approved by the research ethics committee (REC) of the Al-Balqa Applied University, Al-Salt, Jordan, and it was accomplished in agreement with the Declaration of Helsinki (2021/3).

2.2. Study sample

The study's inclusion criteria included the following: (1) remote-learning university students, and (2) aged 18-30 years. During the time of the data collection, lockdown restrictions remained in place, and universities were closed. All data were collected between 1st-30th April 2021 through constructed, administrated, and validated online questionnaires. A total of 599 participated in the study, and only 311 participants who completed the surveys were included in the final analysis thus there were no missing data.

2.3. Measures

Data were collected using a self-reported questionnaire consisting of five parts: (1) demographic data (self-reported weight, height, age, marital status, living partner, sex, and smoking), (2) meal timing questionnaire, (3) PA questionnaire, (4) sleep quality questionnaire, and (5) DQ questionnaire. Body mass index (BMI) was calculated using the formula (weight (kg)/ height^2 (m^2)). Participants were classified into four BMI categories (underweight (<18.5 kg/m^{2}), normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), and obese (30 or more kg/m^2) (Weir and Jan, 2019).

2.3.1. Meal timing and frequency questionnaire

Meal timing was evaluated using the method described in Ha and Song's (2019) study. This included variables such as nightly fasting duration (hours/day) and eating during a certain time including the morning time (breakfast and snacks), evening time (lunch and snacks), and nighttime (dinner and snacks) (Ha and Song, 2019). The duration of nightly fasting (hours/day) was calculated (nightly fasting duration=the last meal episode–the first meal episode) (Marinac et al., 2016). Eating times included: Morning eating (eating between 5:00 AM–9:00 AM), evening eating (eating between 6:00 PM–9:00 PM), and night eating (eating after 9:00 PM). Participants were grouped using the approximate value of the high quantity of food consumed in the main meals (high morning energy, high evening energy, and high night energy) (Allison et al., 2010; Ha and Song, 2019).

Regarding meal frequency, participants were asked to describe their regular eating quantities (highly regular, moderately regular, and irregular) and eating frequency (1-2, 3-4, 5-6, or more than 6 meals/day). Participants were classified into two groups based on the median split for bedtime (before/after 12:30 AM) of the sample in 24 hours: Early bedtime or late bedtime. For wake-up time, they were classified into two groups according to the median value of the study sample (9:08 AM): The early wake-up time group and the late wake-up time group (Zhang et al., 2019).

2.3.2. PA questionnaire

Participants were asked to complete an International PA Questionnaire (IPAQ), reporting the amount of vigorous and moderate activities, walking, and sitting time during the previous month, whereas the total number of metabolic equivalent (MET) minutes was calculated (Maugeri et al., 2020). Based on the MET–min/week of the summation of walking, moderate-intensity PA, and vigorous-intensity PA, participants were classified into three different categories of PA: Low active; moderately active; and high active (Cheng, 2016).

2.3.3. Sleep quality questionnaire

Sleep quality was determined using the Pittsburgh Sleep Quality Index (PSQI), which determined sleep hours using a self-reported questionnaire composed of 4-items. It is composed of seven components, covered by 19 self-evaluation questions. Each component was scored from 0-3. The summation of the total components score gives the total PSQI score (0-21 points). More than 5 scores are considered poor sleep quality, whereas a score≤5 is considered good sleep quality (Buysse et al., 1989).

2.3.4. DQ questionnaire

DQ was evaluated using data obtained from an amended version of the Leeds Short Form Food Frequency Questionnaire (Cleghorn et al., 2016). A shorter form of the food questionnaire was chosen to reduce the subject's burden (time needed to complete the questionnaire) (Merino et al., 2021). Participants were asked how often on average they had consumed one serving of each food category in a usual week. The responses had five frequency groupings: Rarely, once a week, 2-3 times/week, 4-5 times/week, or daily intake. DQS was quantified using the validated healthful plant-based diet index (hPDI) (Satija et al., 2017). To calculate the hPDI, food groups were categorized into quintiles; positive scores were given for healthy plant food groups (positive scoring from 5 for the highest quintile, following through 1 for the lowest quintile), whereas reverse scores were given for animal food groups and less healthy plant foods (inverted scoring from 1 for the highest quintile, following through 5 for the lowest quintile. The summation of scores gave a total score ranging from 12 (lowest DQ) to 60 (highest DQ) points. Participants were later classified into 4 quartiles based on their DQ score (Q1 for the lowest DQ, Q2-Q3 for the moderate DQ; and Q4 for the highest DQ).

2.4. Statistical analysis

Data analysis was performed using SPSS software (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). To assess differences between categorical variables, the chi-square test (χ^2) or Fisher exact test was used, and the results were presented as percentages, whereas continuous variables were analyzed using an independent t-test or one-way Analysis of Variance (ANOVA) and were described using means±standard deviation (SD). Associations were evaluated using Spearman's correlation coefficient. A p-value<0.05 was considered statistically significant.

3. Results

3.1. Study sample characteristics

The total number of study participants was 311, the majority being females (80.3%); the female-to-male ratio was 4:1. Therefore, all the results were stratified into three categories: Female, male, and total participants. Nearly eighty percent of the sample were pre-graduate students aged between 18-21 years. Most of the participants were single (96.1%), non-smokers (86.1%), and living with their families (96.8%). Female students were significantly more likely to be non-smokers compared to males (p<0.001). Most of the participants were of normal weight (62.3%), followed by overweight (17.7%), underweight (12.6), and obese (7.4%). Moreover, the percentage of overweight and obese male students (39.4%) was significantly higher than females (21.7%) (p=0.028) (Table 1).

3.2. PA, sleep quality, and sleep pattern

As shown in Table 2, most of the participants reported low PA (96.5%). About 65.5% of the participants had poor sleep quality based on the global PSQI score. The overall wake-up time and bedtime of the university students during the COVID-19 showed that approximately half of the participants (56.8%) had an early wake-up time (before or at 9:08 AM), whereas the remaining students (43.2%) had a late wake-up time (after 9:08 AM). Female students reported a higher percentage of waking up earlier (57.4%) compared to their male counterparts (54.1%). Therefore, 53.4% of female participants had an early bedtime (before 12:30 AM), whereas 11.6% of male students went to bed after 12:30 AM. In the total study sample, 55.6% of participants had a sufficient sleep duration of 5-10 hours, whereas 44.3% of them had abnormal sleeping hours, distributed to 7.8% of participants who reported a sleep duration exceeding 10 hours, and 36.0% who slept for less than 5 hours per day.

3.3. Assessment of regularity and food consumption patterns

The irregularity of meal timing and quantities was reported almost by half of the study sample (49.7%, and 44.8%; respectively). The vast majority of university students depend on consuming the highest quantity of energy in the evening (73.9%) in alignment with feeling hungriest at lunchtime (58.7%).

The highest proportion of both sexes reported ingestion of three or four meals per day (48.1%) followed by ingestion of one or two meals per day (45.1%). The highest reported percentage of nightly fasting hours in the overall study sample was 11-12 hours (36.9%) of the participants, whereas the lowest reported percentage was 1.3% for more than 16 hours of nightly fasting (Table 3).

Table 1: Characteristics of the study participants

Features		Male N (%)	Female N (%)	Total N (%)	χ^2, *p*-value
Age	18-21 years	47 (77.0)	199 (79.9)	246 (79.4)	0.672
	22-25 years	12 (19.7)	46 (18.5)	58 (18.7)	
	26-30 years	2 (3.3)	4 (1.6)	6 (1.9)	
Marital status	Single	61 (100.0)	237 (95.2)	298 (96.1)	0.217
	Married	0 (0.0)	10 (4.0)	10 (3.2)	
	Divorced	0 (0.0)	2 (0.8)	2 (0.6)	
Living partner	Student accommodation with friends	0 (0.0)	5 (2.0)	5 (1.6)	0.282
	Student accommodation alone	2 (3.3)	3 (1.2)	5 (1.6)	
	With family	59 (96.7)	241 (96.8)	300 (96.8)	
Smoking	No	38 (62.3)	229 (92.0)	267 (86.1)	<0.001**
	Yes	23 (37.7)	20 (8.0)	43 (13.9)	
BMI[3]	Underweight (<18.5 kg/m^2)	4 (6.6)	35 (14.1)	39 (12.6)	0.028*
	Normal weight (18.5-24.9 kg/m^2)	33 (54.1)	160 (64.3)	193 (62.3)	
	Overweight (25.0-29.9 kg/m^2)	17 (27.9)	38 (15.3)	55 (17.7)	
	Obese (30 or more kg/m^2)	7 (11.5)	16 (6.4)	23 (7.4)	

Note. N: Number; χ^2= chi-square test, Statistical significance was denoted as * p <0.05, ** p < 0.001

Table 2: PA, sleep quality, and sleep patterns based on sex

Features		Male N (%)	Female N (%)	Total N (%)	χ^2, *p*-value
PA	Low activity	24 (39.3)	120 (48.2)	144 (96.5)	0.289
	Moderate activity	25 (41.0)	97 (39.0)	122 (39.4)	
	High activity	12 (19.7)	32 (12.9)	44 (14.2)	
Global PSQI score	Good sleep quality	24 (40.0)	82 (33.2)	106 (34.5)	0.320
	Poor sleep quality	36 (60.0)	165 (66.8)	201 (65.5)	
Wake-up time	Early (before or at 9:00 AM)	33 (54.1)	143 (57.4)	176 (56.8)	0.638
	Late (after 9:00 AM)	28 (45.9)	106 (42.6)	134 (43.2)	
Bedtime	Before or at 12:30 AM	25 (41.0)	133 (53.4)	158 (51.0)	0.082
	After12.30 AM	36 (59.0)	116 (46.6)	152 (49.0)	
Sleep duration hours/day	Less than 5 hours	19 (31.1)	93 (38)	112 (36.6)	0.134
	From 5 to 10 hours	40 (65.6)	130 (53.1)	170 (55.6)	
	More than 10 hours	2 (3.3)	22 (9.0)	24 (7.8)	

Note. N: Number; χ^2= chi-square test

Table 3: Regularity and food consumption patterns

Assessed items		Male N (%)	Female N (%)	Total N (%)	χ^2, *p*-value
Regular meal quantities	Irregular	22 (36.1)	117 (47.0)	139 (44.8)	0.305
	Moderately regular	21 (34.4)	70 (28.1)	91 (29.4)	
	Highly regular	18 (29.5)	62 (24.9)	80 (25.8)	
Regular meal timing	Irregular	27 (44.3)	127 (51.0)	154 (49.7)	0.294
	Moderately regular	19 (31.1)	54 (21.7)	73 (23.5)	
	Highly regular	15 (24.6)	68 (27.3)	83 (26.8)	
At which meal do you feel the hungriest?	Breakfast	10 (16.4)	55 (22.1)	65 (21.0)	0.587
	Lunch	37 (60.7)	145 (58.2)	182 (58.7)	
	Dinner	14 (23.0)	49 (19.7)	63 (20.3)	
Energy concentration	Highest morning energy	6 (9.8)	44 (17.7)	50 (16.1)	0.259
	Highest evening energy	47 (77.0)	182 (73.1)	229 (73.9)	
	Highest night energy	8 (13.1)	23 (9.2)	31 (10. 0)	
Meals/day	1-2 per day	28 (45.9)	112 (45.0)	140 (45.1)	0.300
	3-4 per day	26 (42.6)	123 (49.4)	149 (48.1)	
	5-6 per day	7 (11.5)	13 (5.2)	20 (6.5)	
	More than 6 per day	0 (0.0)	1 (0.4)	1 (0.30)	
Nightly fasting hours	< 8 hours	1 (2.9)	11 (8.8)	12 (7.5)	0.605
	8-10 hours	9 (25.7)	35 (28.0)	44 (27.5)	
	11-12 hours	15 (42.9)	44 (35.2)	59 (36.9)	
	13-16 hours	9 (25.7)	34 (27.2)	43 (26.9)	
	>16 hours	1 (2.9)	1 (0.8)	2 (1.3)	

Note. N: Number; χ^2= chi-square test, Statistical significance was denoted as * p<0.05, ** p<0.001

3.4. Assessment of meal timing and frequency

The main meal timing is shown in Fig. 1. About 22% of participants reported that they skipped breakfast, and 62.3% stated that they were non-morning eaters. Participants who reported that they had lunch between 1:00 PM and 6:00 PM were 86.8%. Whereas 57.4% reported that they had dinner after 9:00 PM. Among different meal timing, only the dinner time showed a significant difference between males and females (p<0.001). Female participants who reported consuming dinner between 7:00 PM-9:00 PM were higher than males (49.4%, and 14.8%; respectively), whereas the percentage of male participants who reported consuming dinner at night after 9:00 PM was higher than females (85.2%, 50.6%; respectively).

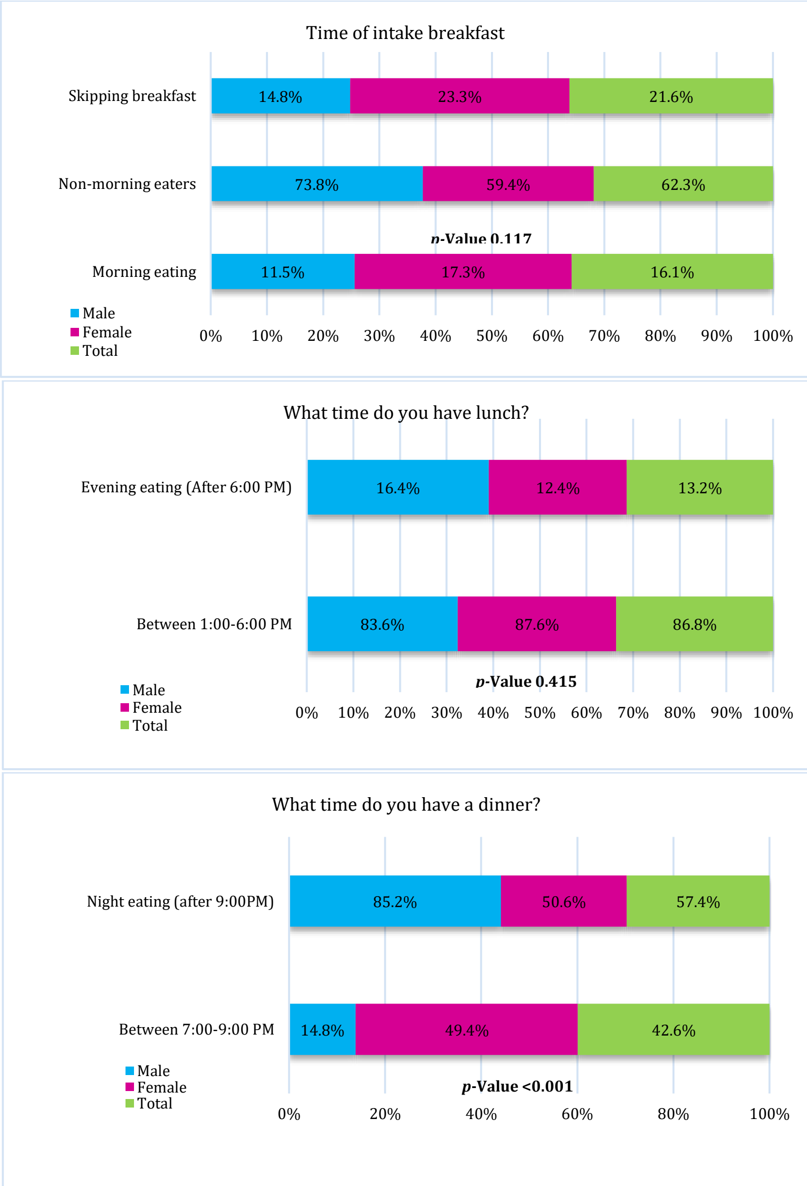

Fig. 1: Time of intake of the three main meals

3.5. Assessment of the DQ

Among the whole participants, only 20.0% followed a high diet quality (DQ4), which is a diet enriched with plant sources and an acceptable amount of animal-derived sources. Yet, the highest percentage of students' scores (53.2%) were observed in the second and third quartiles (Q2-Q3) which represent moderate DQ with moderate intakes of plant and animal-derived foods. Stratified based on sex, females were found to have significantly higher high DQ percentages (22.5%) compared to males (9.8%). However, males had a higher percentage of moderate DQ (68.9%) than females (49.4%) (p=0.016) (Fig. 2).

3.6. The impact of meal timing, regularity, food consumption patterns, and sleep quality on DQ quartiles

As shown in Table 4, high DQ participants reported significantly more highly regular meals quantity and timing (50.0% and 38.2%; respectively), whereas low DQ participants reported more irregular meals quantity and timing (63.9% and 69.9%; respectively) (p<0.001). About 73% and 66% of the high DQ participants reported wake-up early and going to bed before or at 12:30 AM; respectively, and this was significantly (p=0.014) higher percentages as compared to the low DQ participants who reported a higher percentage of wake-up late (50.6%) and went to bed after 12:30 AM (67.5%).

Regarding the onset of a feeling of hunger, most of the participants at all DQ quartiles reported that they were feeling the hungriest at lunch. For DQ quartiles, the high DQ participants reported a higher feeling of hunger at breakfast and lunchtime, whereas the low DQ participants reported a higher feeling of hunger at lunch and dinner time. However, at breakfast time the high DQ participants percentage was significantly the highest (40.3% vs 18.7% for moderate DQ and 10.8% for low DQ; p<0.001), while at dinner time, the percentage of low DQ participants was significantly the highest (25.3% vs. 23.5% for moderate DQ and 4.8% for low DQ).

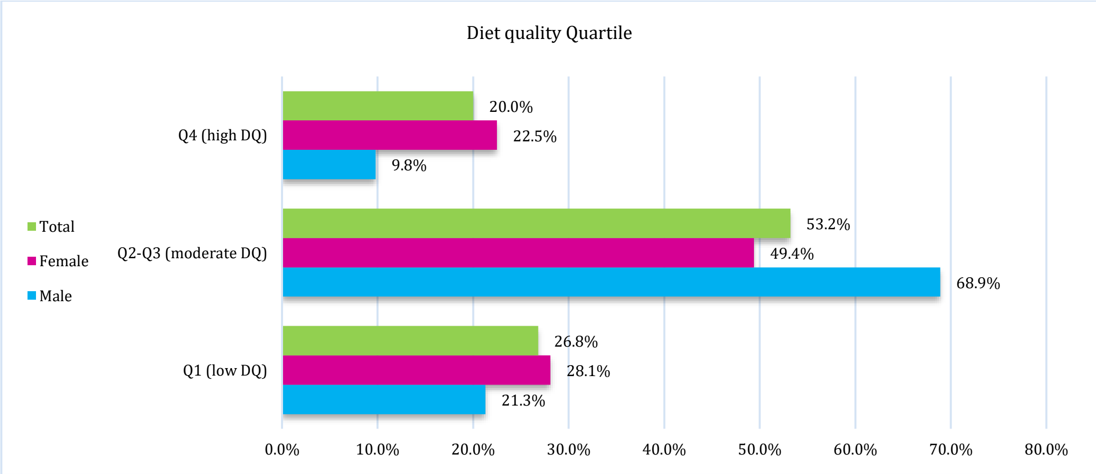

Fig. 2: DQ quartiles. Q1: The first quartile; Q2: The second quartile; Q3: The Third quartile; Q4: The fourth quartile; p-value calculated using the chi-squared test

Table 4: Evaluation of the influence of meal timing, food regularity, consumption patterns, and sleep/wake-up time on DQ quartile

Variables		DQ Quartile Q1[1] (Low DQ2) N (%)	Q2-Q3 (Moderate DQ) N (%)	Q4 (High DQ) N (%)	*χ2, p-value*	r² (*p*-value)
Regular meal quantities	Irregular	53 (63.9)	72 (43.4)	15 (24.2)	<0.001**	0.313** (<0.001)
	Moderately regular	20 (24.1)	55 (33.1)	16 (25.8)		
	Highly regular	10 (12.0)	39 (23.5)	31 (50.0)		
Regular meal timing	Irregular	58 (69.9)	80 (48.2)	17 (27.4)	<0.001**	0.283** (<0.001)
	Moderately regular	14 (16.9)	38 (22.9)	21 (33.9)		
	Highly regular	11 (13.3)	48 (28.9)	24 (38.2)		
Wake-up time	Early (Before or at 9:08 AM)	41 (49.4)	90 (54.2)	45 (72.6)	0.014	-0.149** (0.008)
	Late (After 9.08 AM)	42 (50.6)	76 (45.8)	17 (27.4)		
Bedtime	Before or at 12:30 AM	27 (32.5)	90 (54.2)	41 (66.1)	<0.001**	-0.235** (<0.001)
	After 12:30 AM	56 (67.5)	76 (45.8)	21 (33.9)		
At which meal do you feel the hungriest?	Breakfast	9 (10.8)	31 (18.7)	25 (40.3)	<0.001**	-0.248** (<0.001)
	Lunch	53 (63.9)	96 (57.8)	34 (54.8)		
	Dinner	21 (25.3)	39 (23.5)	3 (4.8)		
Energy concentration	Higher morning energy	5 (6.0)	25 (15.1)	20 (32.3)	<0.001**	-0.255** (<0.001)
	Higher evening energy	65 (78.3)	125 (75.3)	40 (64.5)		
	Higher night energy	13 (15.7)	16 (9.6)	2 (3.2)		
Breakfast time	Morning eating	8 (9.6)	20 (12.0)	22 (35.5)	<0.001**	-0.243** (<0.001)
	Non-morning eaters	48 (57.8)	114 (68.7)	32 (51.6)		
	Skipping breakfast	27 (32.5)	32 (19.3)	8 (12.9)		
Lunchtime	Between 1:00-6:00 PM	70 (84.3)	140 (84.3)	60 (96.8)	0.035	-0.049 (0.388)
	Evening eating (After 6:00 PM)	13 (15.7)	26 (15.7)	2 (3.2)		
Dinner time	Between 7:00-9:00 PM	27 (32.5)	61 (36.7)	45 (72.6)	<0.001**	-0.266** (<0.001)
	Night eating (After 9:00 PM)	56 (67.5)	105 (63.3)	17 (27.4)		
Nightly fasting hours	< 8 hours	1 (2.7)	7 (8.0)	4 (11.1)	0.630	0.020 (0.083)
	8-10 hours	14 (37.8)	21 (24.1)	9 (25.0)		
	11-12 hours	14 (37.8)	31 (35.6)	14 (38.9)		
	13-16 hours	8 (21.6)	26 (29.9)	9 (25.0)		
	>16 hours	0 (0.0)	2 (2.3)	0 (0.0)		

Note. N: Number; χ^2= chi-square test, r^2: Spearman rho. Statistical significance was denoted as * p<0.05, ** p<0.001. [1]Q: Quartile

For energy concentration, most of the participants regardless of the DQ quartiles reported that their energy intake was higher in the evening. Based on the DQ quartiles, high DQ participants significantly had a higher percentage to have a higher energy intake in the morning (32.3%) as compared to moderate (15.1%) or low DQ participants (6.0%). But the low DQ participants significantly had a higher percentage of having a higher energy intake during the night (15.7%) as compared to the moderate (9.6%) and low DQ participants (3.2%). Moreover, more than half of the participants reported that they were non-morning eaters. However, nearly a third of the high DQ participants reported that they had their breakfast in the morning, in contrast to almost a third of the low DQ participant who reported that they skipped breakfast (*p*<0.001). Most of the participants in the different DQ quartiles reported that they had lunch meals between 1:00 PM and 6:00 PM. Though, the participant in high DQ had the highest percentage of eating lunch between 1:00 PM and 6:00 PM (96.8%) and a lower percentage of eating lunch after 6:00 PM (3.2%) significantly (*p*<0.001). In contrast, low and moderate DQ participants who reported that they were night eaters (67.5%, 63.3%; p<0.001 respectively) were significantly higher than high DQ participants (27.4%), who reported that they mostly eat dinner meals between 7:00-9:00 PM (72.6%).

4. Discussion

With the beginning of the COVID-19 pandemic, countries' economies, tourism, education, social, and health, among other vital sectors, came to a standstill (Hong and Peltzer, 2017; Lopez-Minguez et al., 2019). Almost 2.5 years had passed since the start of the pandemic, yet these sectors didn't fully recover nor successfully adapted to the new situation (Al Hourani et al., 2022; Lamarche et al., 2021). Although the closure of various educational institutes and the reliance on online/remoted educational methods were done to contain the COVID-19 spread, this strategy resulted in the onset of a wide spectrum of other health problems among the student population, including university students (Barkley et al., 2020; Du et al., 2021; Taeymans et al., 2021). Improper dietary patterns, impaired physical activities, and poor sleeping qualities were detected among university students during the COVID-19 quarantine worldwide (Ingram et al., 2020; Murphy et al., 2020; Taeymans et al., 2021).

The results of this study showed that most of the participants in the present study reported low PA (96.5%) regardless the sex. This was reported in the bachelor's degree programs students (18-30 years) before and during the COVID-19 lockdown in Saudi Arabia, Jalal et al. (2021) observed a 32% increase in students' weight, associated with a significant decrease in PA parallel to an increase of sedentary time (p=0.0001) (Jalal et al., 2021). Moreover, in a self-reported survey in northern Italy, which was conducted to observe the lockdown effects on lifestyle changes in adults, among the active subjects in pre-lockdown, 14% continued habitual exercising, 18% increased it and 68% reduced it, however, 27% of sedentary subjects started exercising (Cancello et al., 2020). In the same line, total PA in Italian subjects was significantly decreased between before and during the COVID-19 lockdown (2429 vs. 1577 MET–min/week, p<0.0001), in all age groups and especially in males (p<0.0001) (Maugeri et al., 2020). For two months period of lockdown due to the COVID-19 pandemic, the prevalence of non-health-enhancing PA was 37.1% in Swiss universities, students, and employees of applied sciences (Taeymans et al., 2021). A greater sedentary behavior was observed during the lockdown among Italian university students as compared to before the lockdown (p=0.003). While the closure of the universities and remote learning increased sedentary behavior (Barkley et al., 2020), several studies indicated a reduction in PA among university students during the lockdown (López-Moreno et al., 2020; Martínez-de-Quel et al., 2021). Also, greater overeating and a reduction in PA were observed among UK adults during the lockdown (Robinson et al., 2021). Whereas, in the Italian population, weight gain was detected among half of the study population parallel to a slight increase in PA (Di Renzo et al., 2020).

Two-thirds of the participants in the present study had poor sleep quality based on the global PSQI score. The overall wake-up time and bedtime of the university students during COVID-19 showed that approximately half of the participants had an early wake-up time (before or at 9:08 AM). Female participants reported earlier waking up (before or at 9:08 AM) and bedtime (before 12:30 AM) compared to males who reported late wake-up time (after 9:08 AM) and bedtime (after 12:30 AM). In the total study sample, 55.6% of participants had a sufficient sleep duration of 5-10 hours, whereas 44.4% of them had abnormal sleeping hours, and 36.6% slept for less than 5 hours per day. This result matches the Sinha et al. (2020) results which evaluated the effect of COVID-19 lockdown on the sleep-wake pattern and meal timing in adults (age≥18 years). They found that sleep-wake-up times and meal timing were significantly delayed during a lockdown in younger subjects. Furthermore, they reported an increase in sleep duration with increased digital media in all age groups, especially in males. Whereas females show up more interruption in sleep onset-waking hours associated with longer sleep duration (Sinha et al., 2020). Also, Cellini et al. (2021) stated that sleep timing was significantly delayed, time spent in bed increased, and sleep quality was markedly impaired in Italians and Belgians during the lockdown. Another study was carried out on Spanish university students who have a notable prevalence of sleep dysfunctions in half of the study sample (Núñez et al., 2019). In central and southern Italy, it was reported that people slept more hours during the lockdown period as compared to before (Di Renzo et al., 2020). In a cross-sectional study conducted on undergraduate and graduate students in universities in China, Malaysia, Ireland, the USA, South Korea, Taiwan, and the Netherlands, all countries reported poor sleep quality during the COVID-19 pandemic (Du et al., 2021). On the other hand, Cancello et al. (2020) observed that 43% of the study participants had insomnia symptoms, while 13% and 43% of them reported improved and unchanged sleep quality, respectively. The obvious interruption in sleep time and quality could be one of the main factors that enhanced weight gain during the quarantine, as revealed by Sasaki et al. (2018) who found that the long sleep duration variability was significantly associated with a high OR of obesity, especially late bedtime, whereas early wake-up was not.

Furthermore, the present findings showed that the irregularity of meal timing and quantities was obvious among half of the study participants (49.7%, and 44.8%; respectively). Also, most of the participants consumed the highest quantity of energy in the evening, while nightly fasting hours were 11-12 hours (36.9%). Accordingly, this leads to a shift in the timing of the meals during the day, where 21.6% of participants skipped breakfast, 62.3% stated that they were non-morning eaters, and 57.4% reported having dinner after 9:00 PM. Xiao et al. (2019) found that a higher proportion of total daily energy intake eaten during the morning was correlated with lower odds of being excess weight (odds ratio 1.2). Also, a higher proportion of total daily energy intake consumed close to bedtime was linked to higher odds of being overweight or obese (1.07, 3.08) (Xiao et al., 2019). Accordingly, unusual eating time can produce a disruption in the circadian system that might lead to unhealthy consequences (Lopez-Minguez et al., 2019). In Korean adults, Ha and Song (2019) found that meal frequency was inversely associated with the prevalence of different health problems such as abdominal obesity, elevated triglycerides, and elevated blood pressure in males only. In Chinese, Song et al. (2021) found that the evening dominant pattern of eating was associated with increased daily energy intake and correlated with higher fat intake ($p<0.001$). Epidemiologic data approved that breakfast skipping (Bi et al., 2015), late dinner (Chen et al., 2019), and high energy intake near bedtime (Bo et al., 2014) have been connected to numerous markers of cardio-metabolic diseases. In addition, alterations in meal quantity and meal timing can induce energy and macronutrient consumption (Bi et al., 2015; Chen et al., 2019; Bo et al., 2014). A regular meal pattern including having breakfast, consuming a higher proportion of energy early in the day, and regular fasting periods might offer physiological profits such as decreasing inflammation, improvement of circadian rhythmicity, enhancing stress resistance, and gut microbiota modulation (Paoli et al., 2019).

In the current study, a lower percentage of participants (20.0%) who followed a high DQ; which is enriched with plant sources and an acceptable amount of animal-derived sources; was observed. A higher percentage of participants' scores (53.2%) was observed in the second and third quartiles (Q2-Q3) which reflect moderate DQ with moderate intakes of plant and animal-derived foods. However, stratified based on sex, females had a significantly higher percentage in high DQ in comparison to males who had higher percentages in low and moderate DQ. These results were not limited to this study, as it was confirmed in many studies around the world (Batlle-Bayer et al., 2020; Duong et al., 2020; Marty et al., 2021; Du et al., 2021). In France, Marty et al. (2021) demonstrated a decrease in the nutritional quality of diet during the lockdown compared to before ($p<0.001$), in parallel to a significant change in food choice motivations (48% of the study sample). On the other hand, they observed an increase in health (26%), natural content (19%), and ethical concern (21%) due to expanding awareness of the importance of natural food selections in some participants (Marty et al., 2021). Additionally, Bogataj Jontez et al. (2021) found a decrease in the healthy eating index score from 64.6 at baseline to 61.6 during a two-month lockdown in Slovenian adults. Similarly, studies in France and Spain reported a reduction in DQ and an increase in energy intake (Batlle-Bayer et al., 2020; Marty et al., 2021). This was not the case in northern Italy, where 34% of participants reported an improvement in DQ; with 42% of them increasing their food intake, and 13% decreasing their food intake (Cancello et al., 2020). Also, Lamarche et al. (2021) reported that DQ was slightly enhanced, with a reduction in food insecurity among participants during the COVID-19–related early lockdown. This was explained by eating inside the home, instead of eating outside which has been associated with an increased total energy intake and, more energy consumption from fat (Lachat et al., 2012). In the UK, a cohort study of 11,396 adults showed that eating at home more frequently has been associated with a greater observance of the Mediterranean diet and Dietary Approach to Stop Hypertension (DASH), also reported a higher intake of fruits and vegetables and higher plasma vitamin C (Mills et al., 2017)

Data also revealed that high DQ participants reported a significantly highly regular meals quantity and timing, waking up earlier, going to bed before or at 12:30 AM, having a higher energy intake in the morning, and a third of them reported that they had their breakfast in the morning, in contrast to moderate or low DQ participants. The low DQ participants significantly tend to have a higher energy intake at night. Moreover, a third of the low DQ participants reported that they skipped breakfast ($p<0.001$) and were night eaters. Studies that assessed the association between meal or snaking frequency and DQ reported a significant positive association between eating/meal frequency or snack frequency, and DQ (Zhu and Hollis, 2016; Murakami and Livingstone, 2016; Leech et al., 2016). Özduran and Yücecan (2021) suggested that poor DQ among students could be related to many factors such as skipping breakfast and inadequate intake of energy and micronutrients. Likewise, to examine the time-of-day energy intake pattern of Chinese adults, Song et al. (2021) found that the evening dominant pattern of eating was associated with increased daily energy intake and a higher fat percentage of intake ($p<0.001$), while the highest DQ score was observed in participants with a "Noon dominant pattern" ($p<0.001$). Likewise, Leech et al. (2016) reviewed literature about the effect of meal timing/pattern on DQ. They found a consistent inverse association between skipping breakfast and DQ, also they found no consistent association between DQ and other meal patterns, and a tiny investigation has examined the effect of meal timing on DQ (Leech et al., 2016). Zeballos and Todd (2020) found that skipping meals reduces daily energy intake, and skipping breakfast reduced the DQ. In an Australian national survey of children and adolescents, Golley et al. (2013) found late bedtimes and late wake-up times were correlated to poor DQ. The study was limited by standardized measurements of weight and height; it was self-reported relying on participants. Also, cross-sectional research is unable to observe the causal relationship between different variables. A key strength of the present study was the inclusion of a large number of variables that have been linked to DQ.

5. Conclusions

In conclusion, the findings of this study indicate that remote learning is linked to detrimental alterations in both sleep quality and DQ.

Additionally, meal timing and frequency are significantly affected, leading to delays in all meal times. Poor DQ is associated with various factors, including the omission of breakfast, inconsistencies in meal timing and portion sizes, nocturnal eating, late bedtime, delayed wake-up time, and shifting of lunch and dinner times.

Compliance with ethical standards

Ethical considerations

All participants were informed about the study objectives at the beginning of the questionnaire, then they expressed their informed consent to participate, and their data were anonymous. The study was approved by the research ethics committee (REC) of the Al-Balqa Applied University, Al-Salt, Jordan, and it was accomplished in agreement with the Declaration of Helsinki (2021/3).

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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