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Impact of COVID-19 Pandemic on Glycemic Control, Eating Behaviors and Physical Activity in Patients with Type 2 Diabetes: A Retrospective and Cross-Sectional Study in Japan

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Abstract

Introduction: COVID-19 infection has drastically changed the routine lifestyle and physical life of people. These factors pose negative impact on glycemic management in people with diabetes. This study aimed to determine the relationship between glycemic changes, physical activities, and eating behaviors during the COVID-19 pandemic in Japanese patients with type 2 diabetes.

Methods: Study involved both retrospective and cross-sectional data analyses. The glycated Hemoglobin (HbA1c) values in patients with type 2 diabetes before the pandemic in 2019 and during pandemic in 2020 were evaluated. A self-administered questionnaire survey was used to measure physical activity and eating behaviors. Patients with type 2 diabetes who had HbA1c values ≥ 7% at any month during 2020 were included. Data collection was performed at the medical outpatient clinic of Kagawa University Hospital.

Results: Two hundred participants completed the survey. During the COVID-19 pandemic, the average HbA1c values significantly deteriorated (7.72%) than those pre-pandemics (7.57%), with an increase of 1.98 percent (p=0.002, r= -0.157). Additionally, the scores for All Physical Activities (all PA) decreased and total eating behaviors improved. There was no significant relationship was found between the HbA1 values, physical activities, and eating behaviors during the pandemic.

Conclusion: HbA1c levels deteriorated during the COVID-19 pandemic, but this change was unrelated to physical activity or eating habits. The stress factors may contribute to these changes.

Keywords: COVID-19; Type 2 diabetes; Glycemic control; Physical activities; Eating behaviors

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Introduction

The COVID-19 caused by the novel Severe Acute Respiratory Syndrome-Coronavirus-2 (SARS-CoV-2) was first detected in Wuhan in December 2019 and rapidly spread worldwide. In Japan, the first confirmed case of SARS-CoV-2 infection was reported on January 16th, 2020. By the end of August 2021, the total number of domestic infections and deaths increased to 1,469,327 and 15,994, respectively [1]. The mortality cases due to COVID-19 is considerably higher accounting for 1.1% of the infected people, and more than half of the cases recorded involved elderly and people with comorbidities. The Japanese government declared the first state of emergency on April 07th, 2020, for Tokyo and the other six prefectures for one month; on April 16th, 2020, the emergency was extended to the rest of the country, which ended in May 2020 [2]. Compared to scenario in other countries worldwide, Japanese government did not impose a total strict lockdown. However, the emergency declaration disrupted daily routine lives [3] and psychosocial well-being of the people [4,5].

In people with diabetes, maintaining healthy daily life, especially physical activities/exercises and diet are crucial components for improving their glycemic control [6]. There is no conclusive evidence that patients with diabetes are at a higher risk of acquiring COVID-19 infection, but a few studies suggest that diabetes in patients with COVID-19 is associated with a two-fold increased risk of disease severity and mortality [7-9] even in the absence of other comorbidities [10]. A retrospective, multi-centered study of 7,337 cases with COVID-19 in Hubei Province, China, found that patients with poorly controlled diabetes or stress hyperglycemia (blood glucose >180 mg/dl) have a significantly higher risk of severe COVID-19 and increased mortality than the patients with well-controlled blood glucose (blood glucose <180 mg/dl) [8].

In the present study, during routine outpatient assessment of patients with diabetes at Kagawa University Hospital, located in Kagawa Prefecture, we observed an increasing trend of glycated hemoglobin (HbA1c) values in 2020 than those in 2019. To the best of our knowledge, there are limited studies in Japan investigating glycemic changes before and during the COVID-19 pandemic. A retrospective study conducted at the Tohoku Medical and Pharmaceutical University Hospital, Sendai, reported that HbA1c values significantly increased after the emergency was declared [11]. However, the factors of physical activity and diet were not included in this study. Therefore, in the present study, we aimed to evaluate whether there were any significant changes in HbA1c values before (2019) and during (2020) the pandemic. Additionally, we also examined that whether Physical Activities (PA) and eating behaviors relate to higher HbA1c values during the pandemic in 2020.

Materials and Methods

Study design and participants

This was a retrospective, observational, cross-sectional study. Data were collected in two stages: Stage 1 involved retrieving and analyzing data from the hospital's patient information system, and stage 2 involved the patients' survey. Patients analyzed at stage 1 were then followed up for a survey at stage 2 during their hospital visits between November 2020 and January 2021. This was a single-center study conducted at the medical outpatient clinic of the Department of Endocrinology and Metabolism at Kagawa University Hospital in Kagawa Prefecture.

We included all patients who meet the following inclusion criteria; patients with type 2 diabetes, aged ≥ 18 years, on regular consultations (in every 1 to 2 months) in 2020 with HbA1c values ≥ 7% in any month in 2020. In a month, the average number of type 2 diabetes patients with HbA1c values ≥ 7% is approximately 81, thus 230 of patients were randomly selected for this study. We excluded patients with a history of hospitalization during the study period, and those who refused to complete the questionnaire.

Ethical approval

The study was approved by the ethics committee of the Kagawa University (approval number: 2020-155; approval dates: November 20th, 2020). Written informed consent was obtained from the participants, and all procedure adhered to the principles of the Helsinki Declaration of 1964 and later versions.

Data collection

During stage 1, the data extracted from the hospital patient's information system included HbA1c values; age and gender The HbA1c values in 2019 and 2020 were extracted and evaluated.

A self-administered questionnaire was used during stage 2 to measure physical activities and eating behaviors of the participants before and during the COVID-19 pandemic. The Short Diet Behaviors Questionnaire for Lockdown (SDBQ-L) was adapted from a previous study [12] to evaluate the eating behaviors, and the questionnaire was translated into Japanese. The questionnaire enquired five types of eating-related behaviors: 1) Unhealthy food, 2) uncontrolled eating, 3) snacking between meals, 4) binge drinking, and 5) the number of main meals per day. There were four choices as responses and the designated scores for questions 1 to 4 were as follows: "Never" =0; "Sometimes"=1; "Most of the time"=2; and "Always"=3. The responses for question 5 were as follows; "1-2 times/day"=1; "3 times/day"=0; "4 times/day"=1; "5 times/day"=2; and ">5 times/day"=3. The total score of the questionnaire corresponded to the sum of the scores of the five questions. The total score ranged 0 to 15, where "0" indicated no unhealthy dietary behavior and "15" indicated severely unhealthy behavior.

The Japanese version of the International Physical Activity Questionnaire Short Form (IPAQ) was used to measure the extent of PA. It is a self-reported questionnaire that assesses the average frequency and duration of three domains of PA performed over a one-week period, as follows: 1) Vigorous Physical Activity (VPA), 2) Moderate Physical Activity (MPA), and 3) Brisk walking. The Metabolic Equivalent of Task (MET) was computed from the data collected by multiplying the MET value of each PA domain. MET is a unit of measurement for energy expenditure that represents the ratio of the working metabolic rate to the resting metabolic rate. One MET equals one kcal/kg/h of energy expenditure while sitting quietly.

The MET value in each domain was based on the guideline: VPA=8.0 METs, MPA=4.0 METs and Brisk walking =3.3 METs [13]. Total PA was calculated by summing the METs of weekly PA (MET-hours/week) as follows: Total PA (MET-hours/week) = (VPA minutes/week × 8.0 METs) + (MPA minutes/week × 4.0 METs) + (Brisk walking minutes/week × 3.3 METs)/60. This measure has been used worldwide and has been accepted for its reliability and validity in Japanese adults [14].

Statistical analyses

Statistical analysis was performed using SPSS Data Analysis version 25 (SPSS Inc., Chicago, IL, USA) and figures were generated using Microsoft Excel 2019. The Kolmogorov-Smirnov test was used to test for normality. Descriptive analyses were performed on the demographic variables, HbA1c values, PA, and eating behaviors. Data are reported as frequency, percentage, and mean ± Standard Deviation (SD).

The Wilcoxon signed-rank test was used to examine the significant differences in HbA1c levels, PA, and eating behaviors before and during the COVID-19 pandemic. Effect size (Cohen's d) was calculated to determine the magnitude of change in score and was interpreted using the following criteria: 0.2 (small), 0.3 (moderate), and 0.5 (large). Spearman's rho correlation coefficient tests were used to assess the possible relationships between HbA1c values, PA, and eating behaviors. The strength of a relationship was interpreted using the following criteria: r=0.10-29 (small), r=0.30-49 (moderate), and r=0.50-1.0 (large). Statistical significance was set at $p<0.05$.

Results

Demographic characteristics of participants

We successfully reviewed and surveyed 200 patients with type 2 diabetes at our medical outpatient clinic. A total of 30 patients were excluded for several reasons including incomplete data and refusal. Demographic characteristics of the participants are presented in Table 1. Of all participants, 59% were men, with a mean age of 65.5 years, and a mean duration of diabetes of 16.8 years. The participants were primarily unemployed (42%), completed high school education (54.5%), stayed with family (47.5%), and reported no heart disease (80%). The mean weight in 2020 was slightly reduced compared to 2019 with 69.2 kg and 68.3 kg respectively by 1.3%. (z= -3.950,

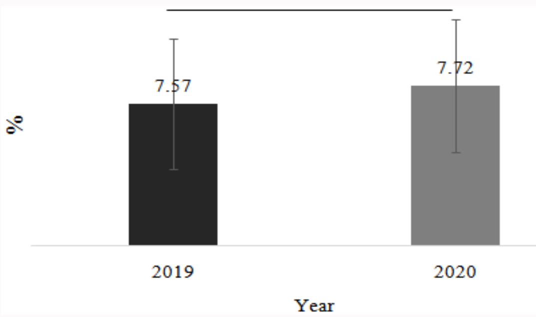

Figure 1: The comparison of average HbA1c values before (2019) and during pandemic (2020). ** Difference is significant at p<0.01 level (2-tailed). A Wilcoxon signed-rank test was used to calculate the p-value and r value (effect size) comparing the HbA1c values in 2019 and 2020.

Table 1: Demographic characteristic of participants.

Variables	n (%)
Gender	
Male	118 (59.0)
Female	82 (41.0)
Age (mean ± SD)	65.5 ± 13.84
Duration of diabetes (mean ± SD)	16.8 ± 11.35
Weight 2019 kg(mean ± SD)	69.2 ± 17.1
Weight 2020 kg (mean ± SD)	68.3 ± 17.2
Family structure	
Living alone	29 (14.5)
Couple	75 (37.5)
Family	95 (47.5)
Others	1 (0.5)
Academic level	
Junior high school	22 (11.0)
High school	109 (54.5)
Junior college	20 (10.0)
University	35 (17.5)
Graduate school	5 (2.5)
Others	9 (4.5)
Working status	
Company employee	37 (18.5)
Self -employed	30 (15.0)
After retirement	22 (11.0)
Unemployed	84 (42.0)
On leave	4 (2.0)
Others	23 (11.5)
Heart disease	
No	160 (80.0)
Yes	40 (20.0)

p=0.000, r= -0.1975). The change of weight in 2020 was significantly associated with total eating behaviors score (p=0.005, r=0.199) but not observed with HbA1c values and PA.

Changes in HbA1c values before (2019) and during the pandemic (2020)

As presented in Figure 1, the average HbA1c values are higher in 2020 than in 2019, with 7.72% and 7.57%, respectively. The values increased significantly during 2020 by 1.98% (z= -3.145, p=0.002, r= -0.157). Figure 2 shows the HbA1c values for each month for both years. Significant differences were found in the months of March (z= -3.450, p=0.001, r= -0.172), April (z= -3.033, p=0.002, r= -0.152), May (z= -2.142, p=0.032, r= -0.107), June (z= -2.789, p=0.005, r= -0.139), and September (z= -2.446, p=0.014, r= -0.122).

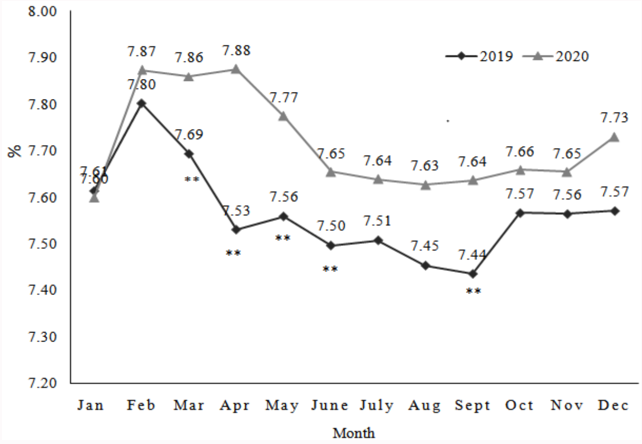

Figure 2: The comparison of HbA1c values for 12 months before (2019) and during pandemic (2020). ** was a significant value of p<0.01 calculated using a Wilcoxon signed-rank test comparing the HbA1c values of the respective month in 2019 and 2020.

Changes in eating behavior scores before (2019) and during the pandemic (2020)

The eating behavior scores before 2019 and during 2020 were 3.61 and 3.51, respectively. During 2020, the score significantly decreased by 2.94% (z= -2.441, p=0.015, r= -0.122). Table 2 presents the responses to each question. A majority of the participants responded "never" (score 0) or "sometimes" (score 1) to most of the questions. During 2020, the scores for Q1 to Q3 decreased, but those for Q4 and Q5 increased slightly. Only Q3 showed that the percentage of score decreased significantly by 6.03% in 2020 (z= -2.6, p=0.009, r= -0.130).

Changes in PA before (2019) and during the pandemic (2020)

The PA of vigorous, moderate, and walking (days/week, minutes/day, MET values) decreased during the pandemic in 2020 than that before pandemic in 2019 (Table 3). However, no significant changes for all types of PA including sitting were found before and during the pandemic. Additionally, we observed a significant change in total all physical activities (all PA) (days/week, minutes/day, MET values), with a small effect size. The number of days/week, minutes/day of all PA, and MET values of all PA during the pandemic decreased by 3.19% (z= -1.998, p<0.05, r= -0.100), 7.69% (z= -2.302, p<0.05, r= -0.115), and 8.02% (z= -2.311, p<0.05, r= -0.116), respectively.

Relationship between HbA1c levels, eating behavior, and PA during the pandemic (2020)

No significant relationship is found between HbA1c levels, PA, and eating behaviors during the pandemic (Table 4). There was a strong positive relationship between days/week, minutes/week, and MET/week for all PA. There was also a moderately negative, significant relationship between average time of sitting and PA (days/week, minutes/week, and MET/week), with longer sitting duration associated with lower PA (days, minutes, and MET in a week).

Table 2: Changes of eating behavior Score before (2019) and during the pandemic (2020).

Item	2019	2020	∆ (% ∆)	Z	*p*	r
Q1:Unhealty food	1.07 ± 0.59	1.03 ± 0.59	0.03(3.73)	-1.46	0.144	-0.073
Q2: Eating out of control	0.98 ± 0.73	0.96 ± 0.69	0.02(2.04)	-0.832	0.405	-0.042
Q3: snacking between meals	1.16 ± 0.66	1.09 ± 0.60	0.07(6.03)	-2.6	0.009**	-0.13
Q4: Alcohol binge drinking	0.30 ± 0.58	0.31 ± 0.56	-0.01(-3.33)	-0.816	0.414	-0.041
Q5: Number of meals/day	0.10 ± 0.32	0.12 ± 0.34	-0.02(-20.0)	-1.069	0.285	-0.053
Total eating behavior score	3.61 ± 1.73	3.51 ± 1.59	-0.11(-2.94)	-2.441	0.015**	-0.122

Difference is significant at p<0.01 level (2-tailed) **. Percentage of changes shown as ∆%. The *Z* and *p* values for comparing the eating behavior responses in 2019 and 2020 were calculated using the Wilcoxon signed-rank test. The r value (effect size) calculated for magnitude of changes

Table 3: Responses to the physical activity questionnaire recorded before (2019) and during the pandemic (2020).

		2019	2020	∆ (% ∆)	Z	p	r
Vigorous intensity	Days/week	0.67 ± 1.61	0.57 ± 1.42	0.1(14.92)	-1.567	0.117	-0.078
	minutes/week	17.30 ± 43.15	14.68 ± 38.77	2.62(15.14)	-1.455	0.146	-0.073
	MET values	451.40 ± 1433.40	364.40 ± 1154.91	87.00(19.27)	-1.128	0.259	-0.056
Moderate intensity	Days/week	1.55 ± 2.28	1.56 ± 2.33	-0.02(1.29)	-0.73	0.465	-0.037
	minutes/week	44.40 ± 76.27	39.74 ± 72.68	4.66(10.49)	-2.972	0.003**	-0.149
	MET values	759.26 ± 1504.60	691.49 ± 1387.21	67.77(8.93)	-2.233	0.026*	-0.112
Walking	Days/week	4.05 ± 2.81	3.92 ± 2.78	0.12(2.96)	-1.9	0.057	-0.095
	minutes/week	64.11 ± 75.51	61.72 ± 71.45	2.39(3.73)	-0.201	0.84	-0.01
	MET values	1152.43 ± 1417.13	1117.72 ± 1351.63	34.71(3.01)	-1.078	0.281	-0.054
All PA	Days/week	6.26 ± 4.83	6.06 ± 4.78	0.20(3.19)	-1.998	0.046*	-0.1
	minutes/week	125.81 ± 141.75	116.13 ± 135.02	9.68(7.69)	-2.302	0.021*	-0.115
	MET values	2363.09 ± 3165.27	2173.61 ± 2926.71	189.48(8.02)	-2.311	0.021*	-0.116
Sitting	minutes/day	329.43 ± 253.10	333.24 ± 252.58	-3.81(1.16)	-1.837	0.066	-0.092

*, **: Difference is significant at p<0.05 level (2-tailed) * or at p<0.01 level (2-tailed) **. All PA (Total all physical activities). Percentage of changes shown as ∆ %. The *Z* and *p* values for comparing the physical activities in 2019 and 2020 were calculated using the Wilcoxon signed-rank test. The r value (effect size) calculated for magnitude of changes

Table 4: Relationship between HbA1c value, eating behaviors, and all PA during pandemic (2020).

	HbA1c	Eating Beh. Score	All PA Days/week	All PA Min/week	All PA MET/week	Sitting
HbA1c	-					
Eating Beh. Score	0.018	-				
All PA Days/week	-0.041	-0.069	-			
All PA Min/week	0.001	-0.019	0.788**	-		
All PA MET/ week	-0.002	-0.027	0.879**	0.964**	-	
Sitting Min/day	0.082	0.083	-0.263**	-0.330**	-0.319**	-

Discussion

In the present study, we analyzed and compared the Glycated Hemoglobin (HbA1c) values in patients with type 2 diabetes before and during COVID-19 that involved the years 2019 and 2020, respectively. We also evaluated whether HbA1c values associated with PA and eating behaviors. The findings suggest relatively deteriorated HbA1c values during the pandemic than those before pandemic. Additionally, the variables of all PA were significantly decreased and the total eating behavior scores was significantly improved during the pandemic. However, we failed to find any variables in the questionnaire that were clearly related to the increasing values of HbA1c. A Japanese study by Tanji et al., [11] involving 1,009 patients with type 2 diabetes, also had a similar outcome, where the HbA1c values worsened after declaration of emergency. Furthermore, women aged ≥ 65 years, those with a BMI ≥ 25 kg/m^2, and those on oral hypoglycemic agents were significantly associated with higher HbA1c values during the pandemic. Compared to values in the present study, the HbA1c values in the study by Tanji et al. [11] were lower by 7.45% and 7.53% before and after emergency, respectively. Moreover, PA and eating behaviors were not investigated in their study.

Recent studies from Japan reported contrasting findings [3,15,16]. Study by Tanaka et al., showed that the HbA1c values after state of emergency (June 2020) were significantly lower than those before, with 7.5% and 7.7%, respectively, and the changed in HbA1cafterthe emergency was related to the changed in body weight [3]. The physical activities descriptively showed a reduction after the state of emergency, however, no association with HbA1c was investigated. Takahara et al. [15], analyzed HbA1c values of 1,402 diabetes patients during the state of emergency (March to May 2020), revealed that 34.9% of patients had increased HbA1c by ≥ 0.3% and only 13.4% decreased by ≤ 0.3% with the mean HbA1c was 7.2%. They found that the changed in HbA1c was related with bodyweight, eating behaviors, leisure-time physical activities, but the other physical activities were not significantly related. Another study by Kishimoto et al. [16], in 168 patients found the change in HbA1c was associated with both changes in physical activities and eating behaviors. Weight gain was observed in patients with increased HbA1c during the emergency period; however the relationship was not statistically evaluated. Compared to outcome of the present study, these studies, only evaluated a single value of HbA1c before and after state of emergency which involved for several months, wherein seasonal variations may have strongly influenced HbA1c fluctuations in Japanese patients with diabetes [17]. Furthermore, the definitions of physical activities might differ between the studies, which contributed to the different findings.

We believe that other factors, such as the stress environment, which was not included in the study, may add complexity to the outcome. When a person physiologically experiences stress and/or anxiety, cortisol and epinephrine are released by the adrenal glands in response to stress. These hormones then trigger the release of glucose stored in various organs that frequently leads to elevated levels of glucose in the bloodstream. This condition causes glycemic deterioration in patients with diabetes [18,19]. Furthermore, people with diabetes mellitus are at risk for developing depression and diabetes mellitus-related distress that are associated with poor glycemic control and cardiovascular complications [19]. In the current COVID-19 pandemic, there is growing evidence of people experiencing stress [5,20,21]. Furthermore, older people with diabetes are more vulnerable to the severity of COVID-19 infection and mortality [22,23]. Thus, fear and anxiety of acquiring COVID-19 and the impact of the situation contribute to stress. People who fail to manage their stress effectively, develop chronic physiological stress, depression, health-related problems, and lack of motivation [5,22]. We could not directly measure stress and cortisol levels, but we believe that studies should be conducted to investigate these aspects in the future.

Japan had not imposed a strict lockdown like many other countries worldwide, but enforcement of COVID-19 management, such as restrictions for outdoor or unnecessary activities, less meeting with peers, social distancing policies, and business restrictions drastically changed the social and daily lives of people, which contributed to factors of stress. In the present study, the frequency and duration of total all PA decreased significantly during the pandemic and demonstrated a significant relationship with a longer duration of sitting. This is not a surprising finding, as staying at home was one of the primary containment measures used to limit the spread of COVID-19. Moreover, many studies worldwide have reported substantial reductions in PA during the pandemic [12,24]. Regular PA is important for improving glycemic control and maintaining individual mental health [6]. However, the restrictions on outdoor activities during the pandemic may have also influenced the emergence of stress in the patients. A previous study conducted with 519 older people in Japan revealed that depression and apathy scores significantly deteriorated in July 2020 than those in December 2019, and that these conditions were more prevalent in people aged <75 years who were constantly active [21].

In the present study, there was a significance changed in eating behaviors during pandemic where the total eating behaviors scores were improved slightly and the changed was related to the reduction of weight in our study population. The score on snacking between meals showed a significant reduction during pandemic. The association between changes in snacking and changes in weight was reported in previous studies [16,25]. A larger online survey among 6,000 participants across Japan revealed that the dietary behaviors in 2020 mostly unchanged (71.6%), healthier (20.3%), and unhealthier (8.2%) compared to 2019, and changed in weight was significantly related to dietary behaviors. In this survey, only 3.5% of the participants had diabetes, and no data on HbA1c can be compared [26]. This finding was different from countries that imposed a complete lockdown. Analysis of a systematic review revealed that the frequency of food intake, meals, and consumption of unhealthy foods/snacks increased during home confinement. Furthermore, psychological changes, such as boredom, stress, distress, and anxiety were associated with people who consumed more food [27].

There are some limitations to the present study. First, the findings of stage 2 were based on participants' self-reported PA and eating behaviors. As these questions required the participants to recall their experiences, misreporting was possible. Second, this study was conducted at a single medical institution with a small sample size and specific characteristics; thus, the findings cannot be generalized to other patients at other medical institutions. Therefore, further studies are necessary to clarify whether PA, eating behaviors, and/or stress affect the changes in HbA1c levels during the COVID-19 pandemic.

Conclusion

The present study showed that there are worse glycemic changes during the pandemic in 2020; however, they are unrelated to PA or eating behaviors. We propose that stress factors may contribute to these changes. Furthermore, as older people with uncontrolled diabetes are more vulnerable to the severity and mortality of COVID-19, crucial interventions to improve the glycemic changes should be implemented, even in the challenging pandemic situation.

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