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ORIGINAL ARTICLE
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Impact of smoking initiation age on nicotine dependency and cardiovascular risk factors: a retrospective cohort study in Japan

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Aims

Initiating smoking in early adolescence results in challenges with smoking cessation and is associated with high risk of cardiovascular disease. Recently, the initiation of smoking has transitioned from adolescence to young adulthood. However, there are few reports on the impact of initiating smoking at a later age. This study investigated the impact of the age of smoking initiation on nicotine dependency, smoking cessation rates, and cardiovascular risk factors, using a cut-off point of 20 years, within the Japanese population.

Methods and results

This retrospective cohort study encompassed 1382 smokers who sought smoking cessation treatment at Kyoto Medical Centre Hospital between 2007 and 2019. Clinical indicators were evaluated by adjusting for age at the time of hospital visit and sex. The smoking cessation rate was further adjusted for treatment medication. The group with a smoking initiation age of <20 years reported a higher number of cigarettes/day ($P = 0.002$), higher respiratory carbon monoxide levels ($P < 0.001$), a higher Fagerström Test for Nicotine Dependence (FTND) score ($P < 0.001$), and a higher Self-rating Depression Scale score ($P = 0.014$). They also reported lower diastolic blood pressure ($P = 0.020$) and a lower successful smoking cessation rate [odds ratio: 0.736, 95% confidence interval (0.569, 0.951)] than the group with a smoking initiation age of ≥20 years. When smokers were divided into four groups based on the age they started smoking, the FTND score for those who started at 20–21 years was significantly higher than the score for those who started at 22 years or older.

Conclusion

In young adulthood, initiating smoking later (beyond 20 years old) was associated with lower nicotine dependency and fewer depressive tendencies, as well as a higher success rate in smoking cessation among Japanese smokers. The results might suggest that raising the legal smoking initiation age from 20 to 22 years old or older could be effective in reducing nicotine dependency in smokers.

Lay summary

Smoking initiation has shifted from early adolescence to young adulthood, but this study advocates further increasing the legal age allowed to purchase tobacco to reduce nicotine dependency and promote cardiovascular health.

- Smokers with a smoking initiation age of <20 years exhibited a higher number of cigarettes per day, higher nicotine dependency, more depressive state, and lower smoking cessation rate than those with a smoking initiation age of 20 years or above.
- Compared with smoking initiation at <22 years old, nicotine dependency is lower in smokers with smoking initiation at the age of 22 years or later.

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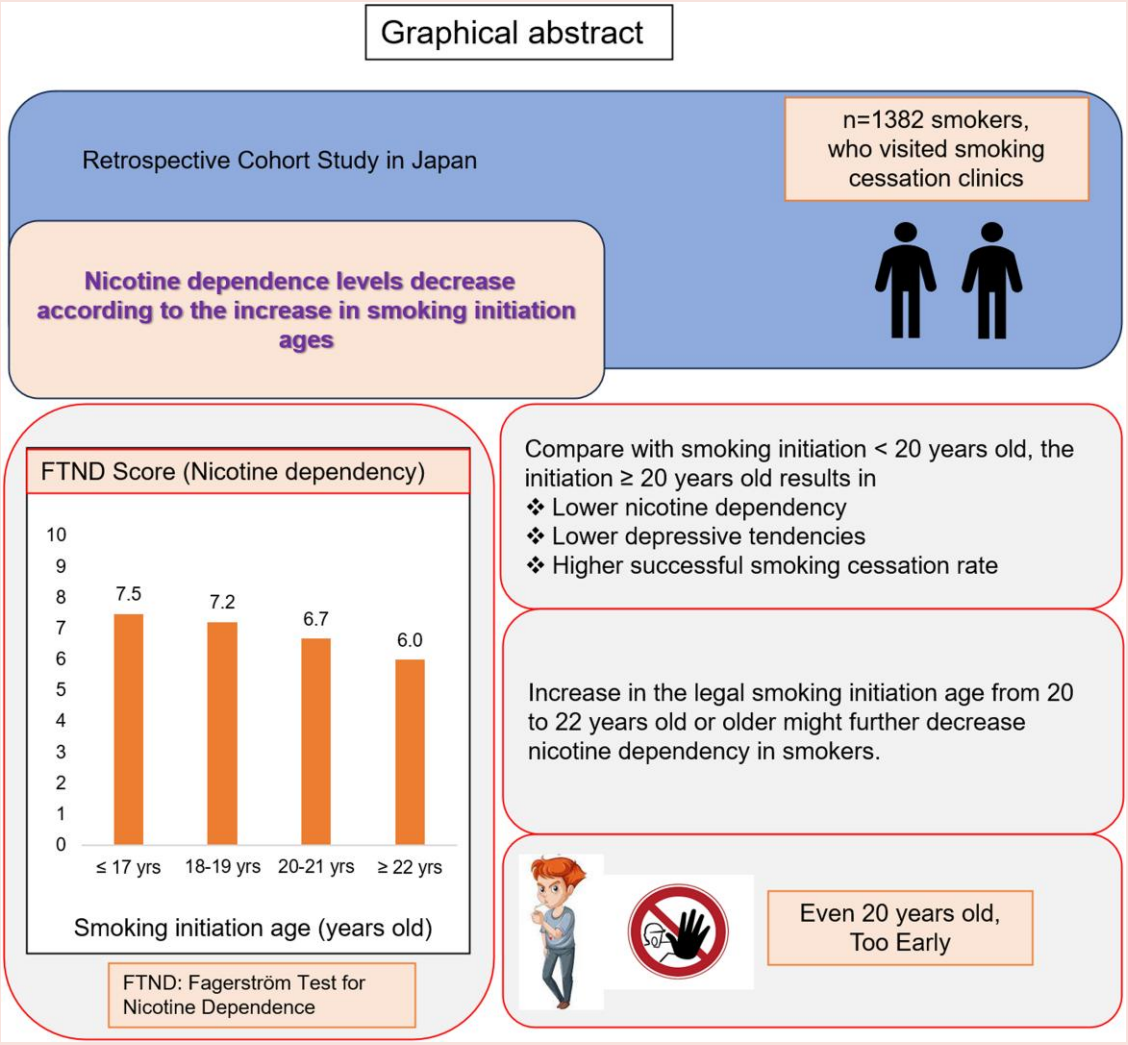
Graphical Abstract



Keywords Smoking initiation • Young adulthood • Nicotine • Addiction

Introduction

Youngsters who start smoking in their teens are more likely to develop a tobacco addiction as adults.[1] Almost every organ in the human body is affected by tobacco use, which can lead to the development of carcinomas, pulmonary diseases, and cardiovascular diseases.[2,3] Despite the extensive reporting of the documented adverse effects of smoking on public health, the prevalence of smoking remains high.

Continued smoking is not a habit but a status dependent on nicotine, a major component of tobacco. Smokers have difficulty or are unable to quit smoking because of nicotine dependency.[4]

Although the legal age for smoking, the age allowed to purchase tobacco, is 18 years in most countries, it ranges from 15 to 21 years. The legal age for smoking in 26 countries in Europe is 18 years[5] but varies in other countries (e.g. it is 15 years in Bosnia and Herzegovina[6] and 16 years in São Tomé and Príncipe,[7] Zambia,[8] and Liechtenstein).[9] The federal law Tobacco 21 (T21) came into effect in 2019 in the USA, where the government increased the minimum age for purchasing tobacco products from 18 to 21 years.[10] This federal law was driven by a substantial body of evidence when the two states, Hawaii and California, implemented T21 policies in 2016 and experienced a subsequent decline in tobacco use.[11] If a person is distanced from tobacco until the age of 21 years, there is a greater chance that they will remain tobacco free for the rest of their lives.[12]

The smokers who started smoking at ≤13 years of age showed higher nicotine dependence levels than those who started late.[13] A study in the USA reported that men with a smoking initiation age ≤ 16 years showed stronger nicotine dependency, a lower number of years of abstinence, and an odds ratio (OR) of 2.1 for not quitting smoking compared with the men who started smoking after the age of 19.[4] Smoking initiation in early adolescence is associated with high cardiovascular disease risk and all-cause mortality.[14,15] The prevalence of cigarette smoking decreased substantially among adolescents aged 12–17 years from 13.0% in 2002 to an all-time low of 2.7% in 2018.[16] On the other hand, the

Table 1 Demographics and laboratory parameters of total participants

Variables	(*n*/total)	Median [IQR]
Females/total	412/1382	
Age at hospital visit		60 [48, 68]
BMI (kg/m^2)		23.1 [20.6, 25.8]
SBP (mmHg)		129 [116, 144]
DBP (mmHg)		77 [69, 86]
HbA1c (mmol)		5.8 [5.4, 6.3]
TG (mg/dL)		147 [96, 225]
HDL-C (mg/dL)		54 [44, 65]
LDL-C (mg/dL)		112 [91, 134]
Cigarettes/day		20.0 [18, 30]
Respiratory CO (ppm)		15 [9, 23]
FTND score (points)		7 [5, 8]
SDS test score (points)		39 [32, 47]
Patients taking medications for dyslipidaemia	469/1382	
Patients taking medications for hypertension	588/1382	
Patients taking medications for diabetes	292/1382	
Patients with history of myocardial infarction	47/1382	
Patients with history of cerebral infarction	183/1382	

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HbA1c, haemoglobin; TG, triglycerides; HDL-C, HDL cholesterol; LDL-C, LDL cholesterol; CO, carbon monoxide; FTND, Fagerström Test for Nicotine Dependence; SDS, Self-rating Depression Scale.

Table 2 Parameters classified according to the age of smoking initiation

Variables	Age of smoking initiation		*P*-value*	*P*-value**
	<20 years old (*n* = 556) Median [IQR]	20 years old or more (*n* = 826) Median [IQR]		
Females	152 (27.3%)	260 (31.5%)		
Age at hospital visit (years)	54 [43, 64]	63 [54, 70]		
BMI (kg/m^2)	23.0 [20.6, 26.1]	23.1 [20.6, 25.5]	0.506	0.470
SBP (mmHg)	128 [114, 142]	130 [118, 145]	0.013	0.051
DBP (mmHg)	77 [68, 86]	77 [69, 85]	0.695	0.020
HbA1c (mmol)	5.7 [5.4, 6.3]	5.8 [5.5, 6.4]	0.054	0.053
TG (mg/dL)	143 [92, 229]	149 [100, 224]	0.550	0.126
HDL-C (mg/dL)	53 [44, 65]	54 [45, 66]	0.124	0.814
LDL-C (mg/dL)	113 [88, 136]	112 [91, 133]	0.881	0.262
Cigarettes/day	20 [20, 30]	20 [15, 25]	<0.001	0.002
Respiratory CO (ppm)	17 [11, 26]	14 [9, 21]	<0.001	<0.001
FTND score (points)	8 [6, 9]	6 [5, 8]	<0.001	<0.001
SDS test score (points)	41 [33, 48]	38 [31, 46]	<0.001	0.014

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HbA1c, haemoglobin; TG, triglycerides; HDL-C, HDL cholesterol; LDL-C, LDL cholesterol; CO, carbon monoxide; FTND, Fagerström Test for Nicotine Dependence; SDS, Self-rating Depression Scale.
*P-value: Mann–Whitney *U* test.
**P-value: ANCOVA test adjusted by age at hospital visit and sex.

average age of smoking initiation and the proportion of new initiates and daily smokers who were young adults increased during this period.[17] Thus, more efforts of tobacco control targeting young adults are needed.

Research demonstrates that smoking initiation in early adolescence (<13 or 16 years) resulted in a lower successful smoking cessation rate.[4,13] A study by Ali *et al.*[18] in the USA found that initiating regular smoking between 18 and 20 was associated with an increased likelihood of nicotine dependence and decreased odds of quitting smoking attempts and intentions. In the study by Ali *et al.*, the legal age according to the T21 policy for purchasing tobacco is 21, and the study examined effects of delaying regular smoking at cut-off age of 21. According to the current law in Japan, the legal age for purchasing tobacco is 20 years,

Table 3 Prevalence of cardiovascular risk factor medications and disease history

Variables	Age of smoking initiation			
	<20 years old ($n = 556$)	20 years old or more ($n = 826$)		
	n (%)	*n* (%)	*P*-value*	*P*-value**
Dyslipidaemia	163 (29.3%)	306 (37%)	0.003	0.519
Hypertension	205 (36.9%)	383 (46.4%)	<0.001	0.524
Diabetes	108 (19.4%)	184 (22.3%)	0.226	0.637
Myocardial infarction	17 (3.1%)	30 (3.6%)	0.651	0.823
Cerebral infarction	56 (10.1%)	127 (15.4%)	0.005	0.504

*P-value: Fisher's exact test.
**P-value: logistic regression analysis adjusted by age at hospital visit and sex.

Table 4 The successful smoking cessation rate classified according to the age of smoking initiation

	Age of smoking initiation		*P*-value*	*P*-value**	*P*-value***
	<20 years old ($n = 556$)	20 years old or more ($n = 826$)			
Medicines taken for smoking cessation					
No medication	88 (15.8%)	122 (14.8%)	0.166		
Nicotine patch	248/556 (44.6%)	411/826 (49.8%)			
Varenicline	220/556 (39.6%)	293/826 (35.5%)			
Smoking cessation rate	243/537 (45.5%)	437/785 (56.0%)	<0.001	0.008	0.019

*P-value: Fisher's exact test.
**P-value: logistic regression analysis adjusted by age at hospital visit, sex, and smoking cessation medicine.
***P-value: logistic regression analysis adjusted by age at hospital visit, sex, smoking cessation medication, number of cigarettes/day, history of cardiovascular disease, and medications for diabetes, dyslipidaemia, and hypertension.

and the sale of tobacco products is prohibited for individuals under this age.[19] Therefore, this study examined a cut-off age of 20. The relationship between smoking initiation age and psychological status is not well known among Japanese population based on their smoking initiation age. The primary objective of this study is to examine the effect of age at smoking initiation with a cut-off point of 20 years or more on the smoking cessation rate, nicotine dependency [Fagerström Test for Nicotine Dependence (FTND) score], and psychological status [Self-rating Depression Scale (SDS) score] among Japanese individuals. The secondary objective is to evaluate the association between age at smoking initiation (with a cut-off point of 20 years or more) and cardiovascular risk factors among Japanese smokers.

Methods

Study population

This was a single-centre, retrospective cohort study including 1382 smokers. The participants in the study were smokers who used traditional cigarettes and demonstrated a nicotine dependency [tobacco dependency score (TDS) ≥ 5] and willingness to quit smoking. None of the participants had previously used e-cigarettes or heated tobacco products. The participants visited the National Hospital Organization Kyoto Medical Centre hospital clinic for smoking cessation between April 2007 and December 2019. All visiting smokers, except those with advanced cancer requiring palliative care, were invited, and patients who agreed to participate in this study were included. Written informed consent was obtained from all participants. This study was approved by the ethical review committee of the National Hospital Organization of Kyoto Medical Centre (Fushimi-ku, Kyoto, Japan).

Participant's current age, sex, number of cigarettes per day, age when they started smoking, and blood samples were taken from their antecubital vein 2–3 h after lunch to determine HbA1c, triglyceride (TG), HDL cholesterol (HDL-C), and LDL cholesterol (LDL-C) levels. The FTND score, SDS, body mass index (BMI), systolic blood pressure (SBP), diastolic blood pressure (DBP), and respiratory carbon monoxide (CO) levels were obtained at the time of first visit to smoking cessation clinic as previously described.[20,21] The FTND (see Supplementary material online, *Table S3*) is a conventional instrument used to measure the severity of nicotine dependence.[22,23] Medications and cardiovascular disease history were taken from the patient at the first hospital visit. The items are added to generate a total score between 0 and 10; the greater the person's FTND score, the more intense their physical nicotine dependence. The SDS is a self-reporting 20-item scale used as a screening tool to assess depression (see Supplementary material online, *Table S4*). The SDS scores range from 20 to 80. Patients were divided into the following three groups based on these ranges identified by Zung[24] and Zung *et al.*[25]: normal (score ≤ 38), borderline neurotic (score = 39–47), and neurotic/depressed (score ≥ 48).

Smoking cessation

The start of smoking cessation treatment was based on standard procedures.[20,21,26] Varenicline and nicotine patches were used to treat smoking cessation. The patients visited the smoking cessation clinic on their first visit and 2, 4, 8, and 12 weeks (3 months). At each visit, the progress of smoking cessation treatment was evaluated, and a nurse and physician provided counselling regarding treatment continuation. In addition, participants who took no medications for smoking cessation were counselled at regular

Table 5 Age- and sex-adjusted logistic regression analysis of smoking cessation rate for each dependent variable

Variables	Ref: group: 20 years old or more		
	OR	95% CI	*P*-value
Age at hospital visit (per 1 year)	1.02	1.01, 1.03	0.042
Sex, M (vs. F)	1.24	0.95, 1.63	0.128
Medication			
No medication	1.000	Reference	
Nicotine patch	19.34	10.93, 34.25	<0.001
Varenicline	22.88	12.81, 40.86	<0.001
Number of cigarettes per day (per 1)	0.99	0.98, 1.00	0.003
Dyslipidaemia medical treatment, yes (vs. no)	1.23	0.94, 1.63	0.144
Oral treatment for hypertension, yes (vs. no)	0.91	0.70, 1.2	0.493
Medical treatment for diabetes mellitus, yes (vs. no)	0.97	0.72, 1.31	0.819
History of myocardial infarction, yes (vs. no)	0.93	0.48, 1.8	0.816
History of cerebral infarction, yes (vs. no)	1.41	0.96, 2.09	0.086
Group: under 20 years old	0.74	0.57, 0.96	0.020

OR, odds ratio; CI, confidence interval.

visits. Maintenance of smoking cessation was evaluated after 12 weeks of anti-smoking treatment. A patient was considered to have successfully quit smoking when presenting with an expiratory CO concentration of ≤7 per million (ppm) and reporting that they had not smoked for >1 week. A patient's attempt to quit smoking was deemed unsuccessful if they discontinued their visits during the treatment period or continued to visit but could not quit. Patients whose CO level data 12 weeks after starting smoking cessation treatment were unavailable were excluded from the smoking cessation success rate calculation. In total, 680 patients reported successful smoking rate at 12 weeks of smoking cessation treatment.

Statistical analysis

A professional statistician conducted all statistical analyses using Statistical Package for Social Sciences (SPSS) Statistics software (version 24.0, for Windows, IBM Japan, Ltd, Tokyo, Japan). The prevalence and associations between the previously described parameters were studied. The normality of data was confirmed using the Shapiro–Wilk test. Continuous non-parametric data were expressed as median and inter-quartile range. Two-group comparisons were performed using Fisher's exact test or the unpaired *t*-test. Comparisons after adjusting for age at hospital visit and sex were performed using analysis of covariance (ANCOVA) or multiple logistic regression analysis.

Results

The study participants consisted of 1382 smokers (29.8% females) with a mean age of 58.2 ± 13.1 years at the time of their first visit to our clinic. *Table 1* presents the participants' data at the initial visit to the smoking cessation clinic. The participants were divided into two groups based on their age of smoking initiation: <20-year-olds and ≥20-year-olds. The age at the hospital visit was significantly lower in the <20-year-old group than in the ≥20-year-old group. In addition, although there was no significant difference between the two groups, the male–female ratio tended to be less in the <20-year-old group. Therefore, we compared variables between the two groups by adjusting age at hospital visits and sex (*Table 2*).

Compared with the group with a smoking initiation age of ≥20 years, the group with a smoking initiation age <20 years reported a greater number of cigarettes/day (20 [20, 30] vs. 20 [15, 25]; $P < 0.001$) and higher respiratory CO levels (17 [11, 26] vs.14 [9, 21]). The <20-year-old group also demonstrated a higher FTND score (8 [6, 9] vs. 6 [5, 8]) with a significant $P < 0.001$ and higher SDS score (41 [33, 48] vs. 38 [31, 46]) with significant $P < 0.001$ (*Table 2*). Patients who started smoking at the age ≥ 20 years also showed a significantly higher DBP than those who started smoking at the age <20 years after adjustment of age at hospital visit and sex (*Table 2*).

Table 3 shows the patients with smoking initiation age <20 vs. ≥20 years with prevalence of cardiovascular disease and other conditions. Smokers with smoking initiation age of ≥20 years show higher levels of dyslipidaemia, hypertension, and cerebral infarction than the smokers with smoking initiation age of <20 years old with significant *P*-values. However, the values were insignificant after adjusting by age at hospital visit and sex.

Table 4 shows patients' smoking cessation success rates classified according to their age at smoking initiation. As data on respiratory CO levels were unavailable for 60 participants after 12 weeks of smoking cessation treatment, they were excluded from the analysis of smoking cessation success rates. The successful smoking cessation rate was higher in the ≥20-year-old age group (56%) compared with the <20-year-old age group (45.5%; $P = 0.008$). The table also mentioned the medications taken for smoking cessation by smokers.

Table 5 shows the age- and sex-adjusted logistic regression analysis for each dependent variable. After adjusting for age at hospital visit, sex, smoking cessation medication, number of cigarettes/day, and history of cardiovascular disease, the OR of the smoking cessation success rate in the <20 years vs. ≥20 years group was 0.74 with a 95% confidence interval of 0.57, 0.96, indicating positive association between the factors adjusted and smoking cessation rate except history of cardiovascular disease.

The patients were divided into four groups based on smoking initiation age: group A, 17 years or younger; group B, 18–19 years; group C, 20–21 years; and group D, 22 years or older (see Supplementary material online, *Table S1*). As shown in *Figure 1*, the FTND score was significantly higher in group B than in group C and in group C than in group D. Furthermore, these differences in FTND scores were significant even after adjusting for age at hospital visit and sex. These findings demonstrate that the risk of developing nicotine dependence decreases when an individual begins smoking at a later age. Moreover, if a person starts smoking at the age of 22 years or more, there is a significant reduction in the nicotine dependence level and increase in DBP after adjusting for age at hospital visits and sex.

Group A had a significantly higher number of cigarettes smoked per day than group B, and this difference remained significant even after adjusting for age at hospital visit, sex, smoking cessation medication, number of cigarettes/day, history of cardiovascular disease, and medications for diabetes, dyslipidaemia, and hypertension. Group A showed a significantly higher SDS score than group B. However, after adjustment of age and sex, the SDS score was non-significant, probably due to the higher number of young female patients in group A. Metabolic parameters change after smoking cessation due to the increase in body weight. Therefore, metabolic and various cardiovascular risk factors, such as dyslipidaemia (HDL-C, LDL-C, and TG) and impaired glucose tolerance (HbA1c), were measured to know the effect of smoking on patients based on smoking initiation age. Group A showed higher HbA1c levels than group B after age adjustment at age at hospital visit and sex with a significant *P*-value of 0.026. Group D showed significantly higher LDL-C levels than group C before adjustment of age and sex.

Figure 1 Fagerström Test for Nicotine Dependence scores among four different groups divided by smoking initiation age. FTND, Fagerström Test for Nicotine Dependence.

However, after adjustment for age and sex, the difference was not significant, possibly due to older patients in group D. Group D showed significantly lower DBP than group C after adjustment for age at hospital visit and sex, with a significant *P*-value of 0.020 (see Supplementary material online, *Table S1*). Group D showed higher SBP as compared with other groups; however, the *P*-value was not significant. The results indicate high level of cardiovascular risk factors in group D than group C.

Supplementary material online, *Table S2* shows the smoking cessation success rates of patients classified among the groups A, B, C, and D. The successful smoking cessation rate was higher in the B group 18–19 years (50%) compared with the A ≤ 17 years age group (39.9%; $P = 0.029$) before adjusting for age at hospital visit, sex, and smoking cessation medication.

Discussion

This study evaluated the effect of smoking initiation age at a cut-off point of 20 years, a higher cut-off point than previously reported, on the successful smoking cessation rate, nicotine dependence, depressive state, and cardiovascular risk factors among smokers. The study revealed that smokers with a smoking initiation age of ≥20 years reported a lower number of cigarettes per day, lower nicotine dependency (lower FTND score), less depressive state (lower SDS score), and higher DBP than smokers with a smoking initiation age <20 years. In addition, the successful smoking cessation rate was significantly higher in the group with a smoking initiation age of ≥20 years than that of <20 years. Furthermore, nicotine dependency further reduces if smokers start smoking at the age of 22 years or later, compared with smokers who start smoking at the age of 20–21.

Previous studies have shown that early smoking onset is associated with increased cardiovascular disease risk and all-cause mortality. According to these studies, the prevalence of cardiovascular disease, especially coronary artery disease, is higher in the groups with smoking initiation age <20 years vs. ≥20 years. For example, one study found that early smoking initiation before age 13 years was associated with increased risks for cardiovascular/metabolic diseases (OR = 1.67) among current smokers.[12,13] Another study[27] found that childhood smoking was associated with an increased risk of cardiovascular mortality in adulthood, even after quitting smoking. However, after adjusting by age at hospital visit and sex, our study results showed no significant association regarding risk of cardiovascular diseases between smoking initiation age <20 years old and 20 years old or more. Our retrospective study targeted patients who visited our smoking cessation clinic. Patients with high cardiovascular risk problems visit smoking cessation clinics in order to reduce their risk. Therefore, prospective studies will be required to precisely determine the relationship between smoking initiation age and cardiovascular risk factors.

Moreover, the findings in our study suggest that early cigarette consumption, which is commonly believed to be experimental and due to peer pressure in early adolescence, leads to future psychological distress. A previous 1-year follow-up study by Jasuja *et al.*[28] reported evidence of smoking and its consequences on depression. Teenagers who smoked but did not have depression have been reported to have a greater than the two-fold increased risk of developing high depressive symptomatology compared with those who did not smoke and did not show depression. This follow-up study[28] was conducted among middle and high school students. The Centre for Epidemiologic Studies Depression Scale (CESD) assessed anxiety, depression, and somatic symptoms. This study reported that cigarette use at the age of 11–13 years resulted in physiological distress at 17–20 years of age. This study found that depression does not appear to be a precursor to heavy cigarette uses among teenagers.[29] In addition, we found that among smokers with a mean age of 58 years at the time of hospital visits, smoking initiation at the age of <20 years resulted in a higher SDS score than smoking initiation at the age of >20 years.

The findings also support the hypothesis that smoking initiation in early adolescence leads to nicotine dependence and difficulties in smoking cessation later in adulthood. Nicotine's brain effects on reward, reinforcement, withdrawal, and dependency are explained in Le Foll *et al.*[30] A study by Goriounova and Mansvelder[31] found that smoking as a teen can affect the prefrontal cortex, which controls thought and feeling. This can impair attention, memory, decision-making, and impulse control. The study also found that adolescent nicotine use may increase the risk of adult mental health issues and addiction. Our retrospective data suggest that initiation of smoking before adulthood leads to the development of nicotine dependence and psychological distress in later life and increases cardiovascular risk factors.

Our results showed that smokers with a smoking initiation age of <20 years smoked more cigarettes per day than those with a smoking initiation age of ≥20 years. When subdivided, those with smoking

initiation ≤17 years smoked more cigarettes than those with smoking initiation at >18 years. These findings are compatible with the results of a study by Chen and Millar[32] who reported that early smoking initiation at the age <17 is associated with heavy smoking than late smoking initiation at the age of 20 or above. Therefore, a smoking initiation age of 18 years can be considered the cut-off point for heavy smokers in the future.

Our study results showed lower smoking cessation success rates among smokers with a smoking initiation age <20 years than among those with an initiation age ≥20 years. However, our study includes very few patients who started smoking at the age of ≤13 years. Thus, quitting smoking can be an unsuccessful process if the person starts smoking at the age of <20 years, which is a higher cut-off point than previously reported.

After adjusting for age at hospital visit and sex, DBP was higher in smokers with an initiation age ≥20 years than in those with an initiation age <20 years and in smokers with an initiation age ≥22 years than those with initiation age 20–21 years. The precise explanation of this phenomenon remains uncertain. Additional research is necessary to elucidate this relationship. However, previous studies reported that elevated systolic, but not diastolic, blood pressure in older men is likely consequent to the well-known increased smoking-related aortic stiffness, a phenomenon that may produce isolated systolic hypertension.[3] In the presence of atherosclerosis, an increase in DBP is associated with a protective effect on prognosis.[26] Thus, a high DBP in smokers with a late initiation age may indicate a better prognosis.

Significantly lower nicotine dependency was observed among smokers who started smoking at 20–21 years compared with those who started smoking at 18–19 years. Nicotine dependency is further reduced when smokers start smoking at the age of 22 years. To the best of our knowledge, this is the first study to report lower nicotine dependency levels using FTND scores among smokers with a cut-off point of 22 years. The federal law T21 came into effect in 2019 in the USA, where the US government increased the minimum age for purchasing tobacco products from 18 to 21 years.[9] The US-based study by Agaku *et al.*[11] reported that middle and high school students' perceptions of buying tobacco products from stores decreased overall between 2019 and 2020. The T21 policies resulted in people aged 18–20 years having a lower likelihood of being current cigarette smokers or smoking cigarettes daily. The results of our retrospective study performed in Japan suggest that increasing smoking initiation from >20 to >22 years of age leads to a further reduction in nicotine dependency. This emphasizes the importance of advocating increasing the legal age allowed to purchase tobacco to 22 years or more in Japan and possibly the world. The study contributes to the existing literature by providing insights into the effects of smoking initiation age on smoking behaviour and related factors specifically among the Japanese population.

Limitations

This study has certain limitations. Firstly, the participants were recruited from a smoking cessation clinic; therefore, they were willing to quit smoking and were not representative of the general population. Second, recall bias could impact these results because participants were asked to recollect the age at which they smoked their first whole cigarette. Lastly, the socioeconomic aspects were not assessed (e.g. education levels and employment).

Conclusions

Our primary analysis, using the current legal age limit as a reference point, demonstrated that smoking initiation at 20 years or older results in lower nicotine dependency and depressive tendencies and a higher rate of successful smoking cessation compared with smoking initiation at <20 years among the Japanese population. The group with an initiation age of ≥22 years reported a lower FTND score than the group with a smoking initiation age of <20 years.

Our study offers valuable insights into the potential benefits of delaying smoking initiation age from age 20 to 22 years or older to reduce nicotine dependency. However, according to the retrospective nature targeting smokers who visited our smoking cessation clinic, further larger-scale prospective studies are necessary to draw definitive conclusions regarding changes to legal smoking ages on a global scale.

Clinical relevance

Delayed smoking initiation

The study indicates that individuals who start smoking at the age of 20 or older exhibit lower nicotine dependency and depressive tendencies and have a higher success rate in quitting smoking. This suggests that delaying the initiation of smoking until the age of 20 or older may lead to better outcomes in terms of addiction and mental health.

Increased smoking initiation age

The findings suggest that increasing the age of smoking initiation to 22 years or older can result in an additional reduction in nicotine dependency. This implies that policies aimed at raising the legal age for tobacco purchase to 22 or older may contribute to reducing addiction rates and improving overall public health.

Lead author biography

Koji Hasegawa, MD, PhD is currently Leader, National Hospital Organization (NHO) Cardiovascular Clinical Research Network, and Director, Division of Translational Research, NHO Kyoto Medical Center. He is also serving as Clinical Professor, Faculty of Medicine at Kyoto University as well as Visiting Professor at University of Shizuoka. He has been widely involved in cardiology from prevention to intervention, and form translational science to clinical medicine. Professor Koji Hasegawa served as a member of Tobacco Expert Group at World Heart Federation (WHF) during 2019-2022. He is internationally active as an Executive Board of Director at International Society of Cardiovascular Pharmacotherapy (ISCP), a Vice President of Asian Heart Society (AHS) and an Associate Editor of European Heart Journal – Cardiovascular Pharmacotherapy.

Data availability

The data supporting this study's findings are available from the corresponding author (K.H.) upon reasonable request.

Supplementary material

Supplementary material is available at *European Heart Journal Open* online.

Author contributions

K.H. designed the research. S.M. conducted the literature search and wrote the first draft of the paper. H.W. checked the data extractions for the accuracy and integrity of the data. H.Y. and N.S.-A. take responsibility for the accuracy of the data analysis. All authors (S.M., M.K., Y.O.,

H.Y., N.S.-A., A.Y., H.W., M.F., Y.K., Y.S., T.M., Ma.A., Mi.A., Y.T., T.N., and K.H.) interpreted the data, revised the subsequent drafts for important intellectual content, and read and approved the final manuscript.

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