

Validity of Self-reported Smoking Using Urinary Cotinine among Vocational High School Students

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Objectives : This study was conducted to validate self-reported smoking among high school students using urinary cotinine.

Methods : A self report of smoking behavior was collected together with urine sample for cotinine analysis from 130 male and female students in two vocational high school students in November, 2007. Validity and agreement between self-reported smoking and urinary cotinine was analyzed with STATA 9.0 for different definitions of current smokers, and frequent and daily smokers. Urinary cotinine concentration was measured by the DRI Cotinine Assay for urine (Microgenics Corp., Fremont, CA) on Toshiba 200FR. The cut-off point of urinary cotinine was 50 ng/dl.

Results : The concentrations of urinary cotinine were significantly different according to the frequency and amount of smoking. Sensitivity and specificity was 90.9%

and 91.8% respectively, and the Cohen's kappa value was 0.787 among the current smokers who smoked at least one day during one month preceding the survey. The comparable high sensitivity, specificity, and kappa value were shown also among the other definitions of current smokers, that is, subjective smokers, and weekly smokers.

Conclusions : The results showed the high validity of self-reported smoking among high school students. However, due to the small sample size and limitation of the participants, it is cautious to generalize the results to overall high school students.

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INTRODUCTION

To prolong health life spans, it is essential to develop healthy lifestyle and to avoid risk behaviors early in the adolescence. Among the risk behaviors, cigarette smoking is one of the most important causal factors of preventable diseases. It is well known the harmful effects of smoking in adolescence on the physical, mental, and socioeconomic aspects not only in adolescence but also in adulthood. In addition, it is more likely that smoking in younger age will lead to be a lifelong smokers. Thus the efforts of smoking prevention should be focused on young adolescence [1,2].

In order to prepare smoking prevention programs for adolescents in local and national level, it is essential to first estimate the prevalence of smoking as accurate as possible. To estimate the smoking prevalence exactly and to compare the results with others, the survey methods should be standardized including the

definitions of smoking behaviors, questionnaire contents, sampling methods, and survey environments. In fact, on reviewing the results of recent surveys of adolescent smoking rates in Korea, big differences were found among survey organizations. For instance, the findings from the 2006 surveys assessing overall smoking rates among middle and high school students varied greatly; 12.8% in the Korea Youth Risk Behavior Web-based Survey (KYRBWS) made by the Korea Centers for Disease Control and Prevention (KCDC); 9.9% in the general survey of harmful environments of juveniles made by the former National Youth Commission; and 4.5% in the National Health and Nutrition Survey made by the Korea Institute for Health and Social Affairs. It is particularly noteworthy from these surveys that the adolescent smoking rate from the National Health and Nutrition Survey was considerably lower than the other surveys. This discrepancy can be explained by the fact that the survey was

conducted via in-home face-to-face interviews, thus there may be a selection bias and a under-reporting caused by low confidentiality for their parents or other family members [3].

In relation to sensitive issues such as smoking, adolescents can be substantially influenced by the survey environment, thus confidentiality must be assured in order to obtain accurate and frank responses. For instance, student surveys in Korea and overseas are most typically conducted in classrooms, so it is desirable to provide the best assurance of confidentiality by excluding teachers from the survey environment and by using external surveyors to implement the survey.

However, smoking rates may be indicated differently not only by the intentional under-reports of students and but also by the different definitions of smoking behavior. The definition of current smoking of adolescent used in the KYRBWS and the National Health and Nutrition Survey was "smoking for one or more days during the last one month." Whereas, the definition by the Korean

Association of Smoking and Health was “smoking occasionally but less frequently than once a week or more frequently than that” and the survey of harmful environments of juveniles by the former National Youth Commission defined it as “smoking occasionally or everyday.” The definition of current smokers of adolescent varies among survey institutions in foreign countries too and many surveys such as the Global Youth Tobacco Survey (GYTS) of the World Health Organization (WHO), the YRBS (Youth Risk Behavior Survey) of Center for Disease Control and Prevention (CDC) in the USA and the European School Survey Project on Alcohol and Other Drugs (ESPAD) in Europe by the Pompidou Group are based on monthly smoking, while Health Behavior in School-Aged Children (HBSC) conducted in collaboration with the WHO Regional Office for Europe and the Australian Secondary School Students Alcohol and Drug Survey of Australia are based on weekly smoking, and the Canadian Tobacco Use Monitoring Survey in Canada is based on daily or occasional smoking [3]. In relation to adolescents, sometimes those who smoke for 20 days or more per month are classified as frequent smokers and those who smoke every day as daily smokers or regular smokers and these are used as meaningful indices [4,5].

Since the survey methods and the definition of smoking may affect the results of smoking assessment surveys, many studies have been conducted in Korea and overseas to review the validity of the self-reported smoking. Several studies in foreign countries have examined the validity of the self-reported smoking among adolescents by measuring nicotine metabolites including cotinine in saliva, urine or serum, and carbon monoxide in expiratory air [6-11]. In Korea, correlation between the self-reported smoking amounts and urinary cotinine was examined in 68 male students in a vocational high school. However, no attempt was made to analyze the agreement between self-reported smoking and urinary cotinine and a description of the method used to measure urinary cotinine

was also missing [12]. In other studies, urinary cotinine tests were performed on 75 students in vocational high schools [13], 631 students in girl’s vocational high schools and boy’s general high school [14] and around 1,200 middle-high school students [15] to verify the validity of the questionnaire surveys. However, these Korean studies measured urinary cotinine using qualitative tests, thus limitations included low sensitivity due to a high detection limit (200 ng/ml) or no presentation of the detection limits. Two other studies except one study [13] contained no definition of smoking or limited the survey to monthly smoking, thus the results could not be applied to other definitions of smoking. Also, in the studies performed to date, Kappa values between smoking and the detection of urinary cotinine were less than 0.5-0.6 thus the questionnaires were not properly validated [14], and other studies were problematic in that they did not present sensitivities and specificities.

Furthermore, in the case of middle school students, it is very likely to obtain false negative results through biological samples such as urinary cotinine because smoking rates and amounts as well as smoking frequencies are very low [9]. Indeed, the results of a Korean study based on monthly smoking found that the Kappa value obtained through urinary cotinine from middle school students was very low at around 0.21 but the positive predictive value obtained through questionnaires was 33.3%, and so cotinine was not detected from the urine of many self-reported smokers [15]. Therefore, it can be said that in the case of middle school students, cotinine tests are not suitable to determine the validity of smoking rates obtained through self reports.

The purpose of this study was to determine the validity of self-reported smoking among high school students on the questionnaire surveys using urinary cotinine measured quantitatively. The self-reported current smokers were classified based on different criteria, and frequent and daily smokers were also validated.

MATERIALS AND METHODS

1. Selection of Participants and Survey Method

This survey was performed by the Daegu Metropolitan Office of Education in November 2007 as a part of the survey of the smoking states of elementary/middle/high school students in Daegu city. Among the schools selected as the survey subjects, one 1st grade and one 2nd grade class were randomly selected from a boy’s industrial high school and a girl’s commercial high school, with the principals agreeing to the implementation of the study. To measure urinary cotinine, agreement sheets were distributed in advance to obtain parental consent.

To reduce survey bias, surveyors were educated in advance using a standardized protocol and a surveyor visited each classroom to perform the self-administered questionnaire surveys. To raise the reliability of the results, student anonymity was ensured by preventing teacher intervention. The surveyors emphasized that there should be no logical error or unanswered questions in the questionnaires and errors were corrected at the time of the survey in case possible. When the questionnaire survey was completed, the students were asked to provide a urine sample immediately or to submit one later to the school infirmary. At this time, matching unique serial numbers were attached to the questionnaire sheets and to the students’ urine cups for identification purposes. Furthermore, to prevent the students from swapping urine samples, a surveyor was positioned at the entrance to the rest room.

A total of 135 students was surveyed; 62 male students and 73 female students. The forms for five students with missing or insincere answers were excluded, thus the final participants for the analysis numbered 130; 61 male students and 69 female students.

II. Questionnaire Contents and the Definition of Variables

Using the definition of current smoker used in foreign countries, the subjects were asked about the number of occasions they had smoked during the previous one month and were separately asked whether they normally smoked at least once a week. The frequency of smoking was categorized into less than 2-3 days, 1-2 days a week, 3-4 days a week, 5-6 days a week, and daily smoking during the last month. The amount smoked was divided into a daily average smoked amount of less than 1 cigarette, 1-5 cigarettes, 6-10 cigarettes, 11-20 cigarettes, 21-30 cigarettes, and 31 or more cigarettes a day.

In relation to the variables used in the study, current smokers were classified using three criteria. Respondents who considered themselves to be smokers were classified as subjective smokers, those who had smoked at least once or more during the previous month were classified as monthly smokers, and those who smoked at least once a week were classified as weekly smokers. Respondents who smoked for at least 5 days a week during the previous month were deemed to have smoked for 20 days or more in the month and were thus defined as frequent smokers, and those who had smoked every day during the previous month were defined as daily smokers [4]. Based on these classifications, a smoker with a higher frequency was also included in groups with lower frequencies, for instance, a daily smoker was included in all groups of smokers, a frequent smoker was included in the weekly and monthly smoker groups, and a weekly smoker was also included in the monthly smoker group.

III. Method of Urinary Cotinine Analysis

Urine samples were placed in cold storage just after collection and were sent to the laboratory and analyzed within 1-2 days. The people who collected the urine and those who analyzed it

had no knowledge of the smoking histories of the subjects. Urinary cotinine concentrations were analyzed using the DRI Cotinine Assay for urine (Microgenics Corp., Fremont, CA, USA) of Toshiba 200FR (Toshiba Lab Medical, Tokyo, Japan). 125 μl of a reagent containing single clone antibodies against cotinine and a substrate for enzymes were added to 20 μl of urine, and reacted with 125 μl of cotinine bound with glucose-6-phosphate dehydrogenase (G6PDH) at 37 °C. To measure urinary cotinine, the optical density of the reaction solution was measured under 340 nm. The urinary cotinine was not adjusted for creatinine level based on the theory indicating that the correlation of urinary cotinine-to-creatinine concentration ratios with a serum cotinine is rather lower than urinary cotinine concentration only [16]. As a criterion for smokers, cases where urinary cotinine concentrations were 50 ng/ml higher were determined to be positive [17].

IV. Data Analysis

To compare urinary cotinine concentrations under different smoking frequencies and amounts, the normal distribution of cotinine concentrations was obtained through natural logarithm conversions and t-tests, and analyses of variance were performed. At this time, although the number of samples in each cell was small, smoking frequencies were divided into four levels in order to present the dose-response relationship between cotinine concentration and smoking frequency. Comparisons were also made between those who smoked for five or more days—the criterion for frequent smoking—and those who smoked less frequently. In relation to quantity smoked, since most of the subjects were distributed between the 1-5 cigarettes and the 6-10 cigarettes a day groups, the subjects were divided into two groups, one of five or fewer cigarettes, and the other of 6 or more cigarettes.

To evaluate the validity of the self-reported smoking, sensitivity, specificity, and percentage

agreement along with Cohen's Kappa value were calculated using the urinary cotinine level as a gold standard, and also the positive and the negative predictive values were calculated. These indices were calculated using STATA ver. 9.0. Based on the criteria suggested by Landis and Koch [18], Cohen's Kappa values were evaluated and determined a value of less than 0 as a poor, 0.00-0.20 as slight, 0.21-0.40 as fair, 0.41-0.60 as moderate, 0.61-0.80 as substantial, and 0.81-1.00 as an almost perfect agreement [18].

RESULTS

There were significant differences between current smokers and non-smokers: the arithmetic mean for those who had not smoked during the last month was 9.9 ng/dl, whereas that of subjective smokers was 644.5 ng/dl, monthly smokers 656.6 ng/dl, and 765.5 ng/dl for weekly smokers. The urinary cotinine concentration for frequent smokers was 840.6 ng/dl and for daily smokers was 875.8 ng/dl.

The urinary cotinine concentrations of monthly smokers in relation to smoking frequency were 165.2 ng/dl in the case of a frequency of less than 1 day per week, 253.0 ng/dl in the case of 1-4 days a week, 740.1 ng/dl in the case of 5-6 days a week and 875.8 ng/dl in the case of every day. These results showed the tendency of urinary cotinine concentration to increase as smoking frequency increased. In particular, there was a big difference between 1-4 days a week smokers and 5-6 days a week smokers.

When smoking frequencies were divided into two groups, a group of 4 days or less a week and another of 5 days or more a week, the urinary cotinine concentrations were 205.1 ng/ml and 840.6 ng/ml, respectively, thus there was a significant difference ($p=0.016$). As for urinary cotinine concentrations in relation to daily average quantity smoked, the concentration in the case of 5 or less cigarettes was 503.4 ng/ml which was significantly different from the

Table 1. Mean values and standard deviation (SD) of urinary cotinine by self-reported frequency and amount of smoking

	no.	Mean ± SD (ng/ml)	Mean ± SD (ln ng/ml)	p-value*
Classification of smoking status				
Non-smoker	92	10.0 ± 55.4	0.22 ± 1.06	
Current smoker				
Subjective	37	644.5 ± 654.9	4.89 ± 2.90	not applicable
Monthly	38	656.6 ± 638.1	5.10 ± 2.75	
Weekly	29	765.5 ± 646.3	5.81 ± 2.14	
Frequent smoker	27	840.6 ± 658.0	5.90 ± 2.22	
Daily smoker	20	875.8 ± 681.6	5.98 ± 2.16	
Frequency of smoking per wk				
< 1 day	6	165.2 ± 258.1	2.77 ± 3.09	0.330
1 - 4 days	5	253.0 ± 273.4	3.56 ± 3.28	
5 - 6 days	7	740.1 ± 623.8	5.64 ± 2.56	
Everyday	20	875.8 ± 681.6	5.98 ± 2.16	
Frequency of smoking per wk				
≤ 4 days	11	205.1 ± 255.6	3.13 ± 3.04	0.016
≥ 5 days	27	840.6 ± 658.0	5.90 ± 2.22	
Amount(cigarettes) of smoking per day				
≤ 5	20	503.4 ± 547.1	4.68 ± 2.85	0.035
≥ 6	18	826.9 ± 702.4	5.56 ± 2.64	

*Statistical analysis by t-test or one-way ANOVA using data transformed as natural log

Table 2. Distribution of the self reported smoking status according to the urinary cotinine level

Self reported smoking		Urinary cotinine level		Self reported prevalence (%) [‡]	
		≥ 50 ng/dl	< 50 ng/dl		
Current smoker	Subjective smoker*	Male	Yes	17	32.8 (20.7-44.9)
			No	4	
		Female	Yes	11	24.6 (14.2-35.1)
			No	1	
		Overall	Yes	28	9
No	5	88			
Monthly smoker [†]	Monthly smoker [†]	Male	Yes	18	32.8 (20.7-44.9)
			No	3	
		Female	Yes	12	26.1 (15.5-36.7)
			No	0	
		Overall	Yes	30	8
No	3	89			
Weekly smoker [‡]	Weekly smoker [‡]	Male	Yes	16	27.8 (16.3-39.4)
			No	5	
		Female	Yes	10	17.4 (8.2-26.6)
			No	2	
		Overall	Yes	26	3
No	7	94			
Frequent smokers [§]	Frequent smokers [§]	Male	Yes	14	24.6 (13.5-35.7)
			No	7	
		Female	Yes	10	17.4 (8.2-26.6)
			No	2	
		Overall	Yes	24	3
No	9	94			
Daily smoker	Daily smoker	Male	Yes	11	19.7 (9.4-29.9)
			No	10	
		Female	Yes	7	11.6 (3.8-19.3)
			No	5	
		Overall	Yes	18	2
No	15	95			

*The one who thought him (her)-self as a smoker, †The one who smoked on at least one day during one month preceding the survey, ‡The one who smoked at least once a week, §The one who smoked on 20 or more days during one month preceding the survey, ||The one who smoked everyday during one month preceding the survey, ¶95% confidence interval

concentration in the case of 6 or more which was 826.9 ng/ml (p=0.035) (Table 1).

The subjects whose urinary cotinine concentrations were 50 ng/dl or higher were 21 males (34.4%) and 12 females (17.4%) for an overall percentage of 25.4%. The percentage

smoking from subjective judgments was 32.8% among males and 24.6% among females and thus the overall percentage was 28.5%; and the percentage of monthly smoking based on self-reporting was 32.8% among males and 26.1% among females and

the overall percentage was 29.2%. The percentage of weekly smoking was 27.8% among males and 17.4% among females and the overall percentage was 22.3%. In addition, the percentage of frequent smokers was 24.6% among males and 17.4% among females and the overall percentage was 20.8%, and the percentage of daily smokers was 19.7% among males and 11.6% among females and the overall percentage was 15.45% (Table 2).

In the case of subjective smokers, the sensitivity by urinary cotinine was 81.0% among males and 91.7% among females and the overall sensitivity was 84.8%; the specificity was 92.5% among males and 89.5% among females and the overall specificity was 84.8%, and the Kappa value was 0.743 among males and 0.697 among females and the overall Kappa value was 0.727. The positive predictive value was at least 90% among both male and females.

In the case of monthly smokers, the sensitivity was 85.7% among males and 100.0% among females and the overall sensitivity was 84.8%; the specificity was 95.0% among males and 89.5% among females and the overall specificity was 91.8%. The Kappa value was 0.816 among males and 0.747 among females and the overall Kappa value was 0.787. The positive predictive value of self reporting was 90.0% among males and 66.7% among females and the overall value was 78.9%, whilst the negative predictive value was at least 90% among both male and females.

In relation to weekly smokers, the overall sensitivity was 78.8% and the specificity was lower than that for subjective smokers or monthly smokers, among both male and females. The specificity was 96.9% and it was higher than that for subjective smokers or monthly smokers among both male and females. The Kappa value was 0.788 which was similar to that for monthly smokers, the

Table 3. Validity, agreement, predictive value of the self reported smoking status according to the urinary cotinine level

Self reported smoking	Validity		Agreement		Predictive value	
	Sensitivity (%)	Specificity (%)	Percent agreement (%)	Cohen's Kappa	Positive (%)	Negative (%)
Subjective smoker						
Male	81.0 (58.1-94.6)	92.5 (79.6-98.4)	88.5	0.743 (0.565-0.921)	85.0 (62.1-96.8)	90.2 (76.9-97.3)
Female	91.7 (61.5-99.8)	89.5 (78.5-96.0)	89.9	0.697 (0.491-0.903)	64.7 (38.3-85.8)	98.1 (89.7-100.0)
Overall	84.8 (68.1-94.9)	90.7 (83.1-95.7)	89.2	0.727 (0.593-0.860)	75.7 (58.8-88.2)	94.6 (87.9-98.2)
Monthly smoker						
Male	85.7 (63.7-97.0)	95.0 (83.1-99.4)	91.8	0.816 (0.663-0.970)	90.0 (68.3-98.8)	92.7 (80.1-98.5)
Female	100.0 (73.5-100.0)	89.5 (78.5-96.0)	91.3	0.747 (0.560-0.934)	66.7 (41.0-86.7)	100.0 (93.0-100.0)
Overall	90.9 (75.7-98.1)	91.8 (84.4-96.4)	91.5	0.787 (0.668-0.906)	78.9 (62.7-90.4)	96.7 (90.8-99.3)
Weekly smoker						
Male	76.2 (52.8-91.8)	97.5 (86.8-99.9)	90.2	0.772 (0.601-0.943)	94.1 (71.3-99.9)	88.6 (75.4-96.2)
Female	83.3 (51.6-97.9)	96.5 (87.9-99.6)	94.2	0.798 (0.608-0.988)	83.3 (51.6-97.9)	96.5 (87.9-99.6)
Overall	78.8 (61.1-91.0)	96.9 (91.2-99.4)	92.3	0.788 (0.664-0.913)	89.7 (72.6-97.8)	93.1 (86.2-97.2)
Frequent smoker						
Male	66.7 (43.0-85.4)	97.5 (86.8-99.9)	86.9	0.688 (0.493-0.883)	93.3 (68.1-99.8)	84.8 (71.1-93.7)
Female	83.3 (51.6-97.9)	96.5 (87.9-99.6)	94.2	0.798 (0.608-0.988)	83.3 (51.6-97.9)	96.5 (87.9-99.6)
Overall	72.7 (54.5-86.7)	96.9 (91.2-99.4)	90.8	0.741 (0.603-0.878)	88.9 (70.8-97.6)	91.3 (84.1-95.9)
Daily smoker						
Male	52.4 (29.8-74.3)	97.5 (86.8-99.9)	82.0	0.555 (0.336-0.775)	91.7 (61.5-99.8)	79.6 (65.7-89.8)
Female	58.3 (27.7-84.8)	98.2 (90.6-100.0)	91.3	0.652 (0.397-0.906)	87.5 (47.3-99.7)	91.8 (81.9-97.3)
Overall	54.5 (36.4-71.9)	97.9 (92.7-99.7)	86.9	0.603 (0.438-0.768)	90.0 (68.3-98.8)	86.4 (78.5-92.2)

(): 95% confidence interval

positive predictive value was 89.7% which was higher than that for subjective smokers or monthly smokers and the negative predictive value was 93.1% which was similar to that for subjective smokers or monthly smokers.

In relation to frequent smokers, the overall sensitivity was 72.7% which was lower than in the cases mentioned above and the sensitivity among males was 66.7% which was especially low. The specificity, Kappa value, positive predictive value and negative predictive value were similar to those of weekly smokers. However, in the case of daily smokers, the overall sensitivity was 54.5%, the Kappa value was 0.603 and the negative predictive value was 86.5%—the lowest compared to other cases—and the specificity and positive predictive values were similar to those for weekly smokers or frequent smokers (Table 3).

DISCUSSION

As non-smoking becomes the social norm, self-reported smoking are often underestimated by the reporting of a reduced amount of smoking or by the denial of smoking itself. Therefore, biochemical evaluations using as gold standards are generally performed to verify the validity of self-reported smoking. To

this end, nicotine or cotinine in plasma, saliva or urine, carbon monoxide in expiratory air, thiocyanate (SCN) in venous blood, saliva or urine, urinary anabasine or anatabine may be measured. Among them, cotinine offers advantages such as high sensitivity and specificity to smoking, a relatively long half-life which is around 19 hours and relatively low costs. Therefore, cotinine measurement is frequently used to verify smoking or non-smoking when nicotine replacement therapy is not prescribed. Cotinine measurement is recognized as the best index for determining if smoking has occurred within 2 days. Among biological samples for cotinine, blood can only be obtained through invasive methods which are difficult to apply in reality. Whereas, in addition that urine can be obtained through non-invasive methods, urinary cotinine is higher in concentration compared to salivary cotinine, thus allowing more time between sampling and measuring and making it more easily measurable, thus this study measured urinary cotinine [6,17,19].

From the results of this study, the urinary cotinine concentrations of monthly smokers and non-smokers were markedly different at 656.6 ng/dl and 9.9 ng/dl, respectively. These results were much higher compared to the

study by Malcon et al. [11] where the average urinary cotinine concentration of monthly smokers was 71.5 ng/dl. This difference may be explained by the different grades of students; the participants of this study was 1st and 2nd grade students in vocational high schools, that is 9th and 10th grade, which were higher than those of 7th and 8th grade students in the above study. Thus it was possible that the smoking frequencies or quantities were higher among the students in this study. In this study, there were also differences in cotinine concentrations not only between smokers and non-smokers based on self-reporting but also between different smoking frequencies and quantities. In particular, there was a remarkable difference between subjects with a smoking frequency of 4 or less days a week and those with 5 or more days a week. Given that the half-life of cotinine is around 19 hours, it is likely that these results reflect the possibility that subjects with a smoking frequency of 4 or less days a week might not have smoked for 1-2 days before the survey day, thus their cotinine concentrations will have decreased considerably. Considering the dose-response relationship of urinary cotinine concentrations based on smoking frequencies and quantities, it is thought that the validity of the method for

analyzing urinary cotinine may be supported.

A remarkable difference between the results from this study and those from previous ones in Korea is that the validity of smoking based on self-reporting was much higher compared to previous studies. In a study of vocational high school students with current smokers constituting monthly smokers only [13], the Kappa value was only 0.28, and in another study that applied the same definition of current smokers [15], the Kappa values were 0.48 among vocational high school students, 0.42 among general high school students, 0.68 among male high school students and 0.18 among female high school students. Above results were much lower than those in this study which were 0.816 among male students, 0.747 among female students and 0.787 for all students. Also, another study performed on male general high school students and female vocational high school students [14], the sensitivities were 48.3% among young male students and 43.9% among young female students which were quite different from those in this study which were 85.7% among male students and 100% among female students.

It is thought that one of the reasons why the results of this study showed excellent validities compared to other studies performed in Korea is that this study performed urinary cotinine tests using quantitative methods with a cut-off point of 50 ng/dl, whereas all other studies were performed using qualitative methods. In a study in foreign country, it was suggested that a qualitative test with a detection limit of 100 ng/ml might be possible to test the validity of the self-reported smoking in some cases [20], but it has been pointed out that tests with high detection limits were not suitable for judging the fact of smoking [21]. In previous studies in Korea describing the detection limit of qualitative tests, it was as high as 200 ng/dl [15] and other studies faced problems of not presenting any detection limits.

Another possible explanation for the high validity in this study was that consent was

obtained from parents for urinary cotinine tests. The students thus knew that the fact of smoking would be checked through urine tests and this might affect their answers. There was a report indicating that the validity of self-reporting increased considerably when the students were notified in advance that the results would be verified by a biochemical test [19]. Accordingly, surveys can be performed using the bogus pipeline method that notifies in advance that a biochemical test will be performed or obtains consents and takes biological samples but in fact does not perform any test [6]. Also, it is thought that the measures taken to ensure confidentiality was helpful to increase validity with efforts such as excluding related parties from the survey process, together with watching students in the restroom to prevent them from swapping urine samples.

In relation to the findings overseas, there have also been considerably different results. Based on a meta study performed in 1990, the results of an analysis of 26 papers showed that sensitivity to confirming smoking based on self-reporting varied greatly between 6% and 100%, and the specificity varied between 33% and 100%, with an average sensitivity and specificity of 87.5% and 89.2%, respectively [6]. According to a study recently performed in Sweden that surveyed 520 adolescents at the age of 15 using salivary cotinine, when the cut-off point used was 5 ng/ml, the sensitivity of the self-reported smoking at least one day during the previous month was 90%, the specificity was 93% and the agreement was 93% and when the cut-off point used was 15 ng/ml, the sensitivity was 93% and the specificity was 92% which were similar to the results in this study [8].

In a study performed in the USA that used Third National Health and Nutrition Examination Survey (NHANES III) data to survey 2,107 adolescents between the ages of 12-17 using serum cotinine measurements, it was found that when a cut-off point of 11.4

mg/ml—calculated using the ROC (receiver operating characteristic curve)—was used, the sensitivity was 81.3% and the specificity was 96.9%. In this case, smokers were defined as those who had smoked at least one cigarette during the previous five days [9]. Another study, in the 2001/2002 National Household Survey on Drug Abuse (NHSDA) performed by the Substance Abuse and Mental Health Services Administration (SAMHSA) in the USA, surveyed 3,759 adolescents ranging in age from 12-17; the study tested the validity of self-reported smoking using urinary cotinine tests, the Kappa value was 0.643, sensitivity was 0.804 and the specificity was 0.864. In this study, the cut-off point for urinary cotinine was 100 ng/ml and the definition for smokers was smoking one or more days during the previous month [10]. A study in Brazil surveyed 1,986 adolescents ranging in age from 13-14 years (7-8 grades) and considered the validity of the monthly smoking and daily smoking using urinary cotinine. The study used urinary cotinine of 10 ng/ml or higher as a cut-off point; the sensitivity of monthly smoking was 16.3% and the specificity was 93.6%; the sensitivity of daily smoking was 6.5% and the specificity was 99.9%. When the cut-off point of urinary cotinine level was 30 ng/ml or higher, the sensitivity of monthly smoking was 22.6% and the specificity was 93.7% and the sensitivity of daily smoking was 11.7% and the specificity was 99.9% [11].

It can be said that the validity of self-reported smoking in this study was better when compared to the results of studies performed in foreign countries as well as those in Korea. One of the possible explanations is the specific nature of the participants in this study. The participants in this study were limited to vocational high school students in a certain region and the prevalence of monthly smoking was 32.8% among males and 24.6% among females; the prevalence of frequent smoking was 24.6% among males and 17.4% among females and the prevalence of daily smoking

was 19.7% among males and 11.6% among females. These findings were a little lower than those for male and female vocational high school students in the 2007 KYRBWS but were much higher compared to general high school students. Among current smokers of monthly smoking, 75% of male students and 70% of female students were frequent smokers, thus in the case of vocational high school students, smoking behaviors have already been maintained and showed a pattern similar to that for adults. In this case, it is thought that smoking would be accepted normatively in this group and thus the possibility of intentional under-reporting would be relatively low compared to general high school students.

Along with the aspects outlined above, it is necessary to consider that most smokers smoke frequently, thus the possibility of false negative results from the urinary cotinine tests is low. When the frequency of smoking is low—as it is for middle school students—there is a possibility that cotinine may not be detected in urine tests due to the relatively short half-life of cotinine. This fact can also be inferred from the fact that in a study by Jeong et al. [15], cotinine was negative in urine tests in only 14.3% of high school student smokers (based on self-reporting) compared to 66.7% for middle school students. Also, since only 130 subjects were studied, there is a limitation associated with the study in that the results can not be generalized to all high school students including general high school students. However, considering that the validity in this study was higher than in other studies of Korean vocational high school students, it can be said that this study suggests the possibility that more accurate results may be obtained if confidentiality can be assured and if supplementary methods, such as the bogus pipeline method, are applied. It is, therefore, necessary to consider the opinion that in order to obtain accurate results to questionnaire surveys, not only the content or composition of

the questionnaires but also the external environments, including confidentiality, are important [22].

In regard to validities from the classification criteria for current smokers, the sensitivity of monthly smokers was 90.9% which was higher than that of weekly smokers at 78.8%, whereas the specificity of monthly smokers was 91.8% which was a little lower than that of weekly smokers at 96.9%. And the Kappa values were the same at 0.79 in both cases. This means that when the monthly smoking criteria is applied, even cases of an irregular but small amount of smoking will be included in the smokers' group. Given that the risk behaviors like smoking are not socially normative, under-reporting rather than over-reporting may be an issue. It would be reasonable to select the method with higher sensitivity even if overall agreements are likely to be similar. In particular, given that small increases in the number of cigarettes consumed during childhood are associated with higher probability of becoming established smokers later, and that even non-smokers with a high susceptibility to smoking are more likely to become adult smokers [23], it is desirable to classify people smoking less than weekly smoking as smokers and to actively intervene to encourage smoking cessation. Besides, in this study, the sensitivities and Kappa values of frequent smokers or daily smokers were low and the same phenomenon appeared in other studies too [13]. This phenomenon can occur because frequent smokers who have a urinary cotinine concentration of 50 ng/ or higher but who smoke for less than 20 days per month are classified with nonsmokers. Therefore, to identify frequent smokers or daily smokers, it is necessary to apply separate criteria to identify them.

Furthermore, in this study, the prevalence of current smokers by the definition of monthly smoking was almost the same as the prevalence of subjective smokers whereas it was higher than the prevalence by the

definition of weekly smokers. At the moment, most surveys including the KYRBWS by the KCDC, YRBS in the USA and the GYTS of the WHO are applying monthly smoking as the definition for current smokers [3]. Based on the result of this study, it is assumed that adolescent smokers generally themselves are recognizing those who have smoked during the last month as smokers. Therefore, it seems unlikely that there would be a significant underestimation of the prevalence of smoking even in cases where the fact of smoking is determined by subjective judgments, as it is in some surveys. On the other hand, the criteria for current smoking based on weekly smoking are likely to underestimate the prevalence of smoking.

Based on the results of this study, in spite of the limitation of participants, the survey method used showed higher validity compared to other studies. If confidentiality and supplementary methods such as the bogus pipeline method were used in tandem, the smoking prevalence obtained through self-reporting would be more accurate for adolescent groups with relatively high smoking rates.

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