The effect of wearing a face mask on body temperature
佩帶口罩對體溫的影響

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Objective: To investigate the effect of wearing a face mask on body temperature in healthy subjects. *Methods:* The study was of repeated measures design. It was conducted from July to August 2003 in two accident & emergency departments on Hong Kong Island. Staff of the two departments, who were free from any active disease at the time of measurement, were recruited. Their body temperature (oral and aural) was measured while they were not wearing a mask and at 30 minutes after they had worn a mask (either surgical mask or N95 mask). Paired t-test was used for significance testing. Pearson product-moment correlation coefficient was calculated to elucidate the relationship between oral and aural temperature measurement. *Results:* Ninety-three subjects were included. Oral temperature was significantly higher when a mask was worn (p=0.002, 95% CI 0.06-0.26). When considered separately, only those wearing N95 mask demonstrated such significance (p=0.005, 95% CI 0.088-0.454). The correlation coefficient for oral/aural temperature measurements was 0.219 (without mask, p=0.035) and 0.169 (with mask, p=0.104). *Conclusion:* Wearing a face mask may increase the oral temperature in healthy subjects. However, the difference may not be clinically significant. (*Hong Kong j.emerg.med.* 2005;12:23-27)

目的：研究佩帶口罩對健康人仕體溫的影響。**方法：**這研究採用重覆量度的設計方式。於 2003 年 7 至 8 月期間在香港島兩所急症室內進行。招募期間沒有任何活性疾病的職員為研究對象。他們在沒有佩帶口罩的情況下先量度體溫（包括口探及耳探），並於佩帶口罩（外科口罩或 N95 口罩）後三十分鐘再行測試。用配對 T 檢驗法測試顯著性，並計算皮爾遜乘積矩相關系數來闡明口探及耳探體溫之間的關係。**結果：**93 名被實驗者中，口探的溫度於佩帶口罩後顯著增高（p=0.002 ，95% 置信區間：0.06-0.26），但分開考慮時，只有佩帶 N95 口罩者證明有顯著的分別（p=0.005 ，95% 置信區間：0.088-0.454）。口探及耳探體溫的相關系數為 0.219（無口罩， p=0.035）及 0.169（有口罩， p=0.104）。**總結：**佩帶口罩可增加健康人仕的口探溫度，但這分別未必有臨床上的重要性。

Keywords: Body temperature, emergency department, face mask

關鍵詞：體溫、急症室、口罩

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Introduction

This study was done during the epidemic of Severe Acute Respiratory Syndrome (SARS). Hong Kong citizens were advised to wear face masks when they were in public places. In the health care setting, the types of masks most commonly worn were either the N95 mask or the surgical mask.

During the epidemic, local citizens were advised to check their body temperature before they went to work or attended school. They would be required to abstain from their usual daily activities if they were febrile. Any person leaving or arriving at Hong Kong was also required to have his or her body temperature checked. If fever was noted, they would be sent to the hospital for check-up. Thus, the accuracy of body temperature measurement had an important bearing on one's daily living during the epidemic. On the other hand, change of body temperature is a common clinical feature of infectious diseases. Medical practitioners often take body temperature measurement as a screening test for infectious diseases. Wearing of face mask may affect the body temperature measurement. This in turn may affect the judgement on whether someone has got an infectious disease. Thus, research is needed to examine this issue. The purpose of this study was to investigate the effect of wearing a face mask on body temperature in healthy subjects.

Study design and method

Study design

Repeated measures design.

Study setting and population

This study was performed at the accident and emergency departments of two urban public hospitals in Hong Kong. It was conducted from July to August 2003. Convenience sampling was used, with staff of the two departments recruited. They were free from any active disease at the time of measurement.

Study protocol and measurements

Subjects were voluntarily recruited into the study. Their body temperature (oral and aural) was measured while they were not wearing a mask and at 30 minutes after they had worn a mask (either surgical mask or N95 mask). Their body temperature was measured orally by an electronic thermometer (Welch Allyn SureTemp), which was put sublingually for one minute. Aural temperature was measured by an infrared aural thermometer (Braun Thermoscan Pro 3000). It was put in the right ear for one second. According to the manufacturer, the displayed reading was the actual measured ear canal temperature plus a mathematical adjustment to approximate the familiar oral range. All measurement was done in the morning. The age and gender of the subjects and the type of mask worn were also recorded. The subjects were allowed to carry out their usual activities at work, but eating and physical exertion were not allowed. Measurements were made by the same investigator with the same instrument.

Data analysis

Data were collected and entered into SPSS (SPSS for Windows, version 8.0.0, SPSS Inc., 1989-1997) Data Editor for further analysis. All analysis and interpretation of data were done using the same statistical software. Paired t-test was used to detect any significant difference between the temperature measurements when the face mask was worn or taken off. Pearson product-moment correlation coefficient was calculated to elucidate the relationship between oral and aural thermometer measurement.

Results

Totally 93 subjects were recruited, with 28 males and 65 females (Table 1). The age distribution is shown in Table 2. Exactly two thirds of them wore surgical mask, with the remaining one third wore N95 mask (Table 3).

Table 1. Sex distribution

Gender	Number of subjects	Percentage (%)
Male	28	30.1
Female	65	69.9

Table 2. Age distribution

Age (years)	Number of subjects	Percentage (%)
20-30	37	39.8
31-40	38	40.9
>40	18	19.3

Table 3. Type of mask used

Mask type	Number of subjects	Percentage (%)
Surgical mask	62	66.7
N95 mask	31	33.3

Oral temperature was significantly higher when a mask was worn (p=0.002, 95% CI 0.06-0.26) (Table 4). When considered separately, only those wearing N95 mask demonstrated such significance (p=0.005, 95% CI 0.088-0.454), while such significance was not found in those wearing surgical mask (p=0.07, 95% CI -0.009 to 0.227) (Table 5).

On the other hand, although the mean aural temperature was higher when a mask was worn, it was not statistically significant (p=0.38, 95% CI -0.05 to 0.12) (Table 4). When considered separately, no statistical significance in aural temperature existed for individual type of masks (Table 6).

The correlation coefficient for oral/aural temperature measurement was 0.219 (without mask, p=0.035) and 0.169 (with mask, p=0.104). There was weak and positive correlation between the two measurements, with about 3-5% of the variability in one measurement could be accounted for by its linear relationship with the other measurement.

In addition, simple factorial ANOVA was performed to test for any difference in mean body temperature change among different possible confounding factors including gender (p=0.65-0.73) and age group (p=0.16-0.65). The result was non-significant. That means there was little or no evidence that the two mentioned factors per se might cause the contrasting temperature change.

Discussion

The human body is able to maintain a constant core temperature by using a combination of physiological mechanisms. Heat is produced from the body itself,

Table 4. Comparison of oral and aural temperatures with and without mask. Temperature was measured in degrees Celsius

Temperature (°C)	Mean (Range)	SD	Paired t test with 95% CI of the difference
Oral temp, no mask	36.56 (35.8-37.7)	0.40	P=0.002
Oral temp with mask	36.73 (36.7-37.7)	0.40	0.06-0.26
Ear temp, no mask	36.49 (35.5-37.4)	0.42	P=0.38
Ear temp with mask	36.53 (35.1-37.5)	0.45	-0.05 to 0.12

SD=standard deviation; CI=confidence interval
(All difference are measured by that with mask minus that without mask)

Table 5. Difference in oral temperatures using different types of mask

Mask type	Mean difference (°C) (Range)	Paired t test with 95% CI
Surgical mask	0.11 (-1.3 to 1.3)	P=0.07 -0.009 to 0.227
N95 mask	0.27 (-0.8 to 1.6)	P=0.005 0.088 to 0.454

CI=confidence interval
(All difference are measured by that with mask minus that without mask)

Table 6. Difference in aural temperatures using different types of mask

Mask type	Mean difference (°C) (Range)	Paired t test with 95% CI
Surgical mask	0.07 (-0.8 to 1.3)	P=0.215 -0.042 to 0.184
N95 mask	0.03 (-0.6 to 0.9)	P=0.637 -0.153 to 0.095

CI=confidence interval
(All difference are measured by that with mask minus that without mask)

principally through the metabolism of hydrocarbons (from food) and skeletal muscle contraction. On the other hand, heat is lost from the body by conduction, convection, radiation and evaporation.[1]

It is believed that the preoptic area of the hypothalamus is the main thermoregulatory centre of the body. Thus, the temperature of arterial blood perfusing this site can reasonably be considered to represent the true core temperature. However, routine measurement of this temperature is obviously impractical. When measuring the body temperature, it is an estimate of the body's core temperature that is being sought. There are sites on the body where major arteries pass close enough to the surface for a reasonable estimate to be made. In our setting, both oral and aural sites are used as convenient ways for body temperature measurement in adults.

When taking a person's temperature orally, the thermometer should be placed firmly in the pockets on either side of the frenulum below the tongue, which measures the temperature of the blood in the carotid arteries. The accuracy of oral temperatures could be threatened by some external factors, including ingestion of hot and cold liquids, respiratory diseases with tachypnoea, and inability to cooperate.

Aural temperature devices use measured infrared radiation emissions from the tympanic membrane to determine body temperature. The instrument we used displays readings, after additional adjustments, to represent the temperature as if at 'oral' sites.

The interesting findings in our study probably could be explained by that wearing a face mask for a certain period of time could increase the temperature inside the oral cavity by minimising the convection and evaporation of heat from the mouth to the surrounding.

Often body temperature is taken immediately when someone attends for medical consultation, without taking into account whether the person has been wearing a face mask or not. Our study provides information on the extent to which wearing a mask may affect body temperature measurement in healthy subjects. Additional information is provided on the correlation between oral and aural temperature measurement.

Although this study showed a statistically significant increase in oral temperature measurement when someone is wearing a face mask, the study showed a narrow range of temperature difference (0.06-0.26 in general, 0.09-0.45 for N95 mask) only. It may have little or no influence in clinical terms.

This may be the first study investigating on such issues. Medical staff, when making judgement on whether someone has got an infectious disease, may need to consider the wearing of face mask as one of the factors affecting body temperature measurement. Probably further studies are required to delineate whether our findings could extend to those subjects who are febrile or ill.

Correlation coefficients (Pearson r) of subjects' temperature measurements were calculated to compare the aural method to the oral method, with r=0.17-0.22, which differed from previous studies, like Chamberlain et al (r=0.83-0.89),[2] Erickson et al (r=0.77-0.85),[3] and Flo et al (r=0.60).[4] Such differences could be accounted for by the difference in study design and types and techniques in the use of thermometers.

One of the criteria on definition of SARS as proposed by the World Health Organization is 'high fever >38°C'. Many institutes in Hong Kong advised their staff or students to abstain from work or school when they had temperature above 37°C. However, no clear guidelines were given on 'how' body temperature should be measured.

It is often controversial and difficult to determine the 'normal range' of body temperature and to decide a definite cut-off temperature to say someone has got a 'fever'. Although not a large-scale study, our study may provide some hints on this issue.

For oral measurement, none of the subjects in our study got temperature above 38°C, while 13% and 18% of those not wearing and wearing masks respectively got temperature above 37°C. Only 5% of them got temperature above 37.3°C and 37.5°C when not wearing and wearing masks respectively.

Similarly, for aural measurement, none of them got temperature above 38°C, with a significant proportion (9-13%) got temperature above 37°C. Only 5% in both groups (wearing and not wearing masks) got temperature above 37.3°C.

Judging from the above findings, it may be more advisable to set the cut-off temperature at 37.3°C in all aural measurement and oral measurement without mask as the value for screening those with febrile illness. The respective value for those wearing masks with oral measurement should be 37.5°C.

Limitations

Some studies demonstrated a higher body temperature in females as well as children.[5] However, the small sample size of our study limited our effort to delineate such relationships between different age groups and genders.

Another drawback of our study is that the subject's activity was not limited, although physical exertion was not allowed. Difference in activity level might introduce bias in temperature measurement.

Finally, if time is allowed, the duration of wearing a mask could be extended to see whether it would alter our findings. In reality, people may wear mask for several hours or even a day during the outbreak of an infectious disease, like SARS.

Conclusions

Our study found that wearing face mask may increase reading in oral temperature measurement in healthy subjects. However, the difference may not be clinically significant. Better-controlled studies are required to delineate whether such findings could be extended to those who are febrile or ill.

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