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# Usefulness of a Simple Device to Measure Aural Canal Temperature

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In patients with spinal cord injury, rectal temperature is difficult to use as body temperature due to impairment such as defecation disturbance. We developed an earphone type device to measure aural canal temperature that can be also used during exerciie in patients with spinal cord injury and evaluated its usefulness. The subjects consisted of 11 healthy male students. They exercised for 30 minutes using an ergometer until the heart rate increased to 150-160 bpm. Aural canal temperature, rectal tempeeature, and non-contact tympanic membrane temperature were measured before, during, and after exercise.

This device for the measurement of aural canal temperature was produced by cutting the tip of a commercially available earphone and connecting a thermooouple wire to it. This device is very small and causes no discomfort even during long wearing or inconvenience during exercise. The aural canal temperature obtained in this study was very stable compared with the rectal temperature or non-contact tympanic membrane temperature and thus may be useful for monitoring body temperature. (Ann. Physiol. Anthrop. 12(3) : 189-194, 1993)

**Key words :** Body temperature, Aural canal temperature, Spinal cord injury, Exercise

Rectal temperature is most frequently used as an index of body temperature during exercise in exercise physiology and sports medicine for the following three reasons: (1) Convenient retention of a thermometer. (2) Freedom from the influence of ambient temperature changes. (3) Stable measurement during locomotive exercise. We are in the process of studying the body temperature-regulating function of patients with spinal cord injuries (SCI). Previous reports indicate that rectal temperature is most frequently used in studies of the body temperature of patients with SCI on exertion (Gass and Camp, 1984 ; Gass et al., 1988). However, the use of rectal temperature as a core temperature is problematic in patients with SCI, in whose rectum feces and gas frequently remain because of defecating disorders due to SCI. In addition, it is very difficult for such a patient to insert a thermometer into the rectum. Therefore, another type of clinical thermometer, which can be readily used on exertion in place of a rectal thermometer, needs to be developed to protect patients with SCI who have more inconvenience than do normal individuals in defecation from mental anguish. We have produced an earphone-type thermometer for measurement of aural canal temperatures. To evaluate the efficacy of measurement of aural canal temperatures on exertion, we carried out an exercise tolerance study using ergometers for comparison of changes in aural canal temperature with those in simultaneously measured rectal and non-contact tympanic membrane tempempeures.

## METHODS

The subjects were 11 healthy male college students who were physically active (18-22 years of age). The experiment was carried out in a room with a temperature of 25℃ and a relative humidity of 56%. After inserting a thermocouple rectal temperature probe about 10 cm into the rectum, the examinees entered the experimental room, only wearing shorts. Our earphone-type aural canal thermometer (Fig. 1) and a cardiograph (PE-3000; Polar Electro, Finland) were attached to them. The time until attachment was about 20 minutes. After sitting on ergometers (Monark) at rest for 10 minutes, the examinees began 30-minute exercise. The pedaling frequency was 50 or 60 rpm. Three stages of loading was used: 5 minutes for warming up, a period of grrdual increase and the final period during which the heart rate remained at 150-160 bpm. After the end of exercise, the examinees remained seated on the ergometers at rest for 10 minutes. Aural canal and rectal temperatures were recorded at 5-second intervals starting 5 minutes before the start of exercise (Data Collector AM -2000; Anritsu Meter, Japan). As a result of a preliminary test, it was decided for each examinee to measure non-contact tympanic membrane temperature by inserting a probe (Quick Thermo; Omron, Japan) into the ear cavity by himself. This temperature was measured at 5-minute intervals starting immediately before the start of exercise.

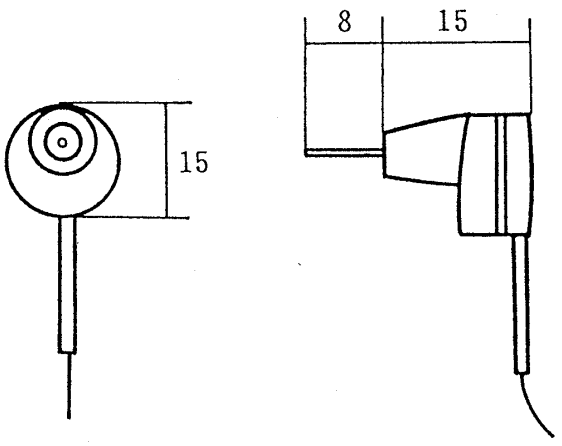


**Fig. 1** Earphone-type ear thermometer to measure human aural canal temperatures.

## RESULTS

Figure 2 shows changes in the aural canal temperature of each examinee at 5-minute intervals. The aural canal temperature at rest showed individual differences at 36-36.6℃ at rest, and individual differences increased after the start of exercise. In several examinees, the temperature showed a transient initial decrease by 0.1-0.3℃ up to 5 minutes after the start of exercise, but rose after 5 minutes of exercise to reach a mean of 37.42oC (36.9-38.2℃) at the end of exercise. The temperature dropped rapidly after the end of exercise in all examinees, with a mean of 37.16℃ (36.6-6-.9℃) 5 minutes after the end of exercise and 36.91oC (36.4-37.5℃) 10 minutes later.

Rectal temperature showed less individual differences than did aural canal temperature at both rest and exercise, with a mean of 36.9-37.4℃ at rest and 38-39.1℃ at the end of exercise. These values were higher by 0.6-1.2℃ and 0.6-1.5℃, respectively, than those of aural canal temperature. The elevation of rectal temperature during exercise was more linear than that of aural canal temperature, with definite indivivial differences in the variations after exercise (Fig. 3).

Figure 4 shows changes in the non-contact tympanic membrane temperature of each examinee. The temperature was 36.7-37.8℃ immediately before the start of exercise and 37.8-39.1℃ at the end of exercise. The values during exercise indicated rapid increases and decreases which were unlikely to be body temperature changes, suggesting the difficulty of temperature measurement on exertion. Significantly high correlations with aural canal temperaturr were observed (Fig. 5).

## DISCUSSION

Core temperature on exertion is measured in the rectum, esophagus and tympanic membrane. Rectal

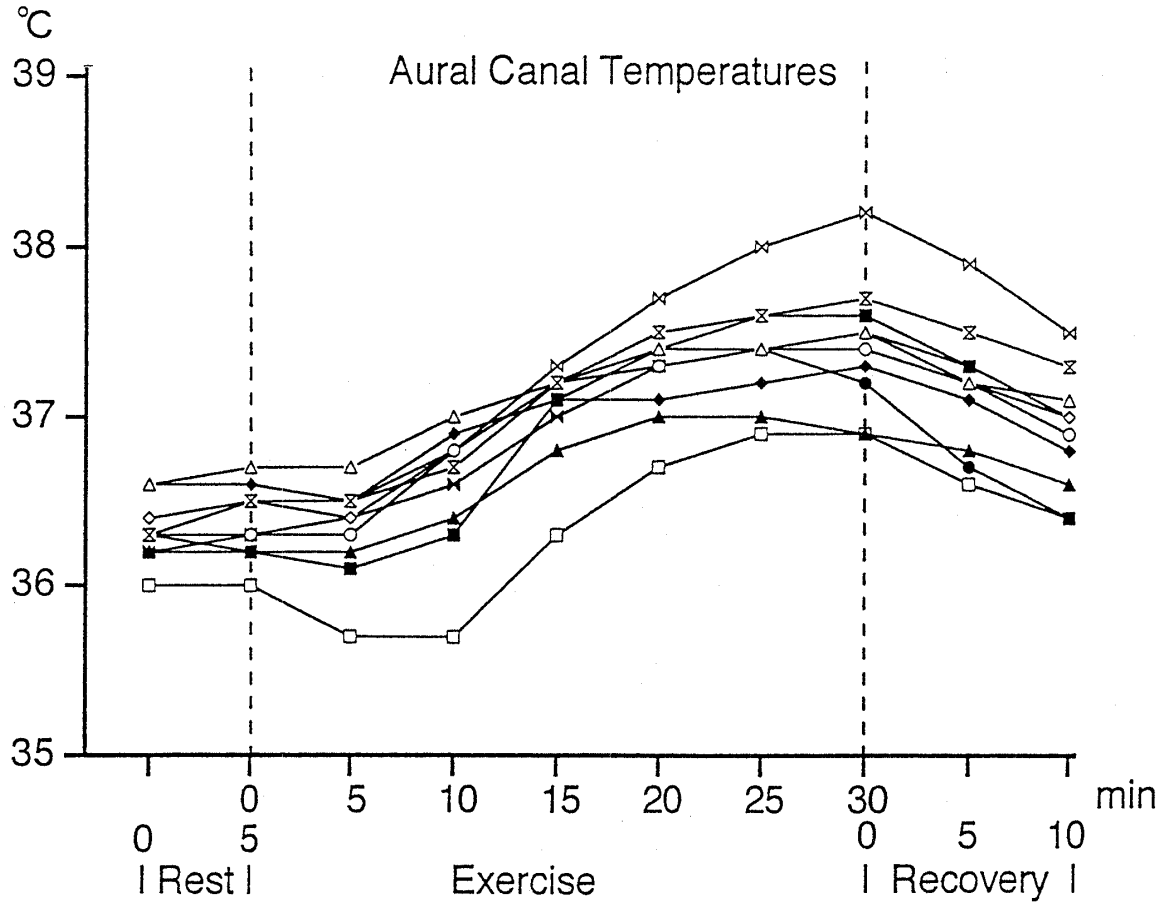


**Fig. 2** Aural canal temperatures during ergometer exercise (load: heart rate 150-160 bpm).

temperature is controversial, because many researchers do not regard it as actual body temperature, and because there should be no feces or gas, if possible. Nevertheless, because of its convenient measurement and stable values, rectal temperature is a very useful monitor of body temperature variations on exertion and is frequently used. However, tympanic membrane temperature is currently considered to be the most reliable index of core temperature. The body temperature-regulating function is greatly influenced by hypothalamic temperature. Benzinger and Taylor (1963) and Benzinger (1969) reported that tympanic memmrane temperature represented hypothalamic temperature, because a portion of the blood in the internal carotid artery is supplied to the hypothalamic area and tympanic membrane. This theory was supported by Baker et al's study (1972) in cat and monkey However, there were few reports on tympanic membrane temperature on exertion because of the difficulty in attaching a thermometer to the tympanic membrane and the risk of injuring the external meatus and tympanic membrane.

Non-contact tympanic membrbre temperature (Shinozaki et al., 1988; Kelly and Alexander, 1991; Muma et al., 1991), which is now used in the clinical setting, is usable for studies of exercise physiology and sports medicine, if it can be measured during exercise. However, this temperature needs to be measured in terms of the volume of infrared rays emitted from the tympanic membrane, and such a measurement during exercise with accuracy seems

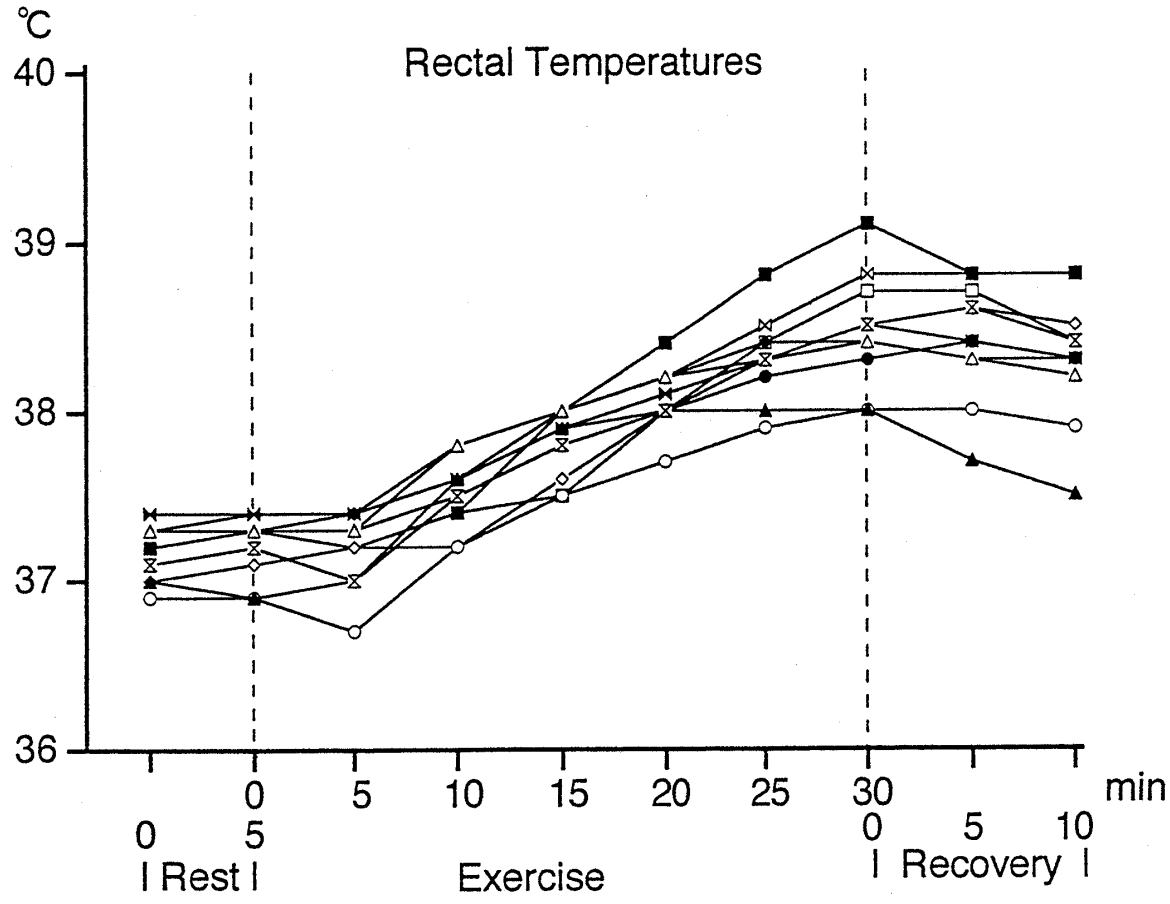


**Fig. 3** Rectal temperatures during ergometer exercise (load : heart rate 150-160 bpm).

difficult. In addition, the rate of radiation of infrared rays may change in reaction to perspiration. In this study, some of the values of non-contact tympanic membrane temperature obtained during exercise were unstable, suggesting that its use during exercise requires careful consideration.

Aural canal temperature, which can replace tympanic membrane temperature, poses a problem of being influenced by ambient temperature at measurement. Keatinge and Sloan (1975) reported the usefulness of their aural canal thermometer with an ear cover from a headphone. However, this device covers the entire ear, causing discomfort in long-lasting measurement and is too large for measurement during exercise. Our earphone-type aural canal thermometer was produced by cutting the tip of a commercially available earphone and attaching a thermocouple. It is very small, and none of the examinees complained of discomfort after attachment for many hours, or any inconvenience during exercise. Although changes in aural canal temperature do not accurately represent temperature changes in the internal carotid artery (Uchino, 1988), the measured values in this study (Fig. 6) indicated body temperature changes with stability, compared with rectal and non-contact tympanic membrane temperatures. Therefore, aural canal temperatures measured with our earphone-type thermometer are suggested to be a convenient monitor replacing rectal temperatures in detecting body temperature changes in patients with SCI.

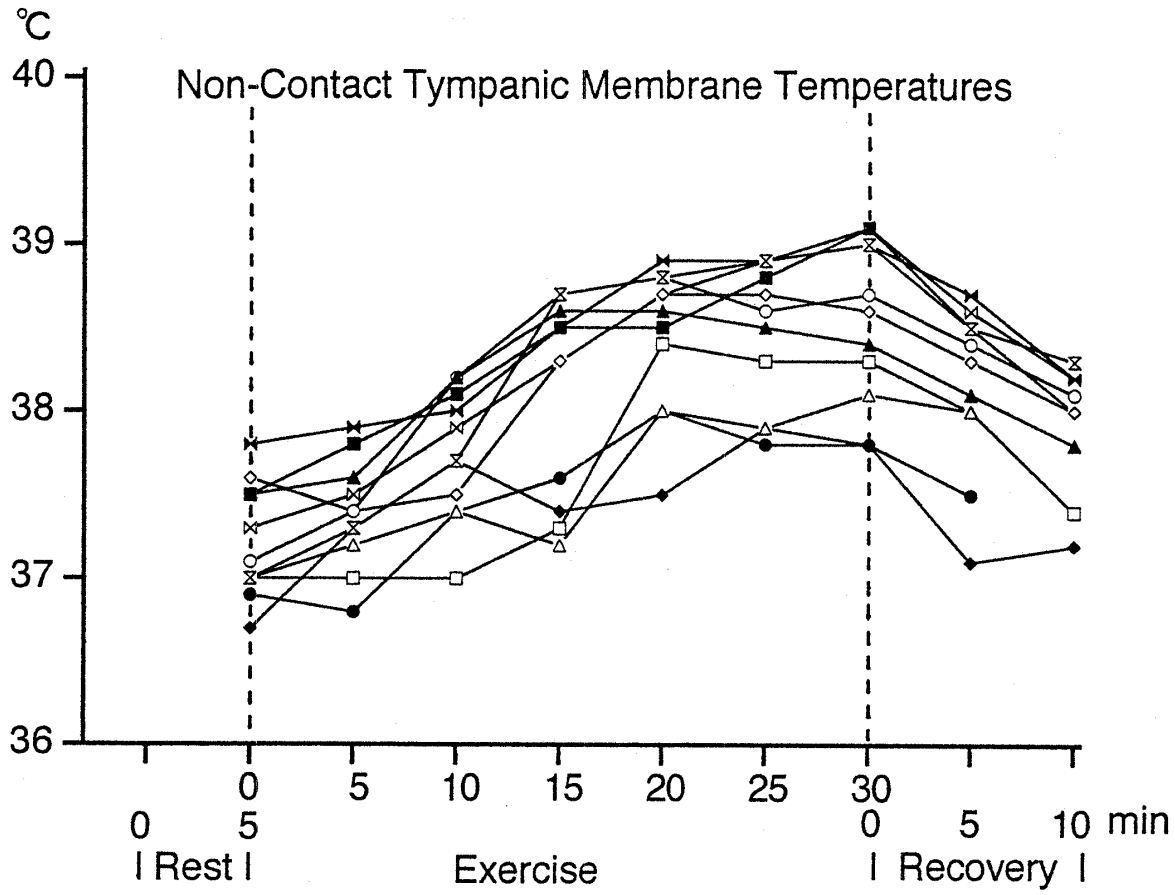


**Fig. 4** Non-contact tympanic membrane temperatures during ergometer exercise (load: heart rate 150-160 bpm).

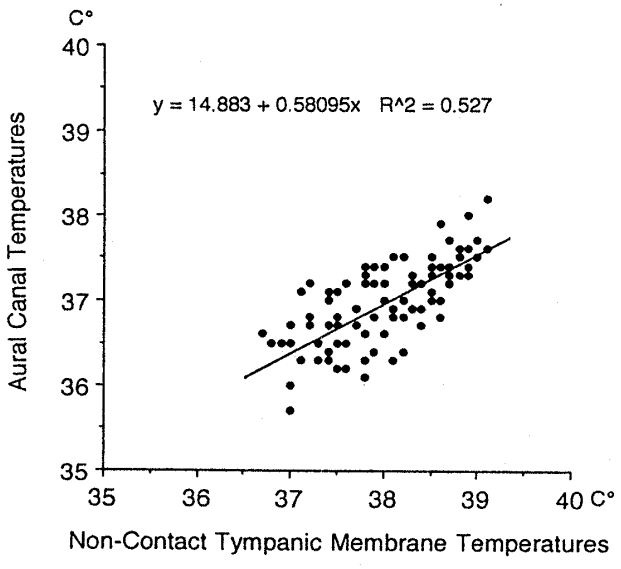


**Fig. 5** Relationship between aural canal temperatures and non-contact tympanic membrane temperatures.

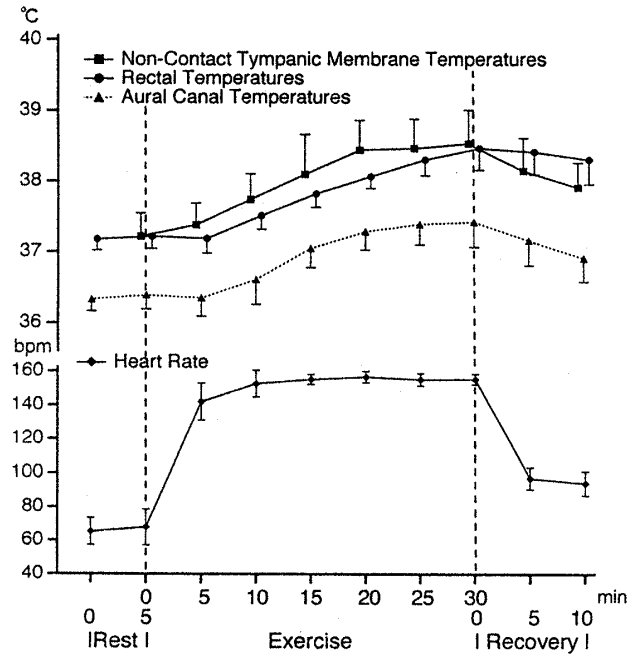


**Fig. 6** Changes (mean±SD) in non-contact tympanic membrane, rectal, aural canal temperatures and heart rate due to exercise on an ergometer.

## ACKNOWLEDGMENT

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