Changes in Intragastric pH and Temperature due to Physical Exercise in Man.

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Abstract

For the purpose of studying the effect of physical exercise on the digestive work of the stomach, the determinations of some variances of gastric function by means of transistor radio-capsule swallowed into the stomach can be made without giving constraint to the subject and makes possible to get continuous informations of the gastric function in physiological state. Measurements of intragastric pH and temperature were made with a telemetering system. As the subjects served 5 healthy men whose age ranged from 23 to 33 years. The experiments were generally conducted 16–18 hours after the last meal. It was ascertained in advance that the capsule stayed longer than 80 minutes in the stomach after swallowing.

The intragastric pH at rest was 1.56 ± 0.13 on the average in post-absorptive state and 2.38 ± 0.66 on the average 1 hour after having 200g beefsteak.The intragastric temperature at rest was 37.26 ± 0.24°C on the average in post-absorptive state. In case of mild exercise, where the heart rate reached 100 beats/min, the intragastric pH showed increase of about 10–20% and recovered the initial level in less than 3min after exercise, and the intragastric temperature was kept almost unchanged. In case of heavy exercise, causing 173–185beats/min of heart rate, the intragastric pH showed increase exceeding 30%, and the intragastric temperature showed 0.9–1.5°C of rise.

However, the authors could not find significant correlation between the peak heart rate which was the index of exercise intensity and peak value of intragastric pH. It seems to the authors that physical exercise in post-absorptive state generally causes an increase in the intragastric pH, namely, a decrease in acidity of gastric juice, suggesting inhibition of digestive activity of the stomach.

However, it seems that the relation between the exercise intensity and the inhibition of gastric juice secretion is not definite, namely, it cannot be said, the heavier the exercise, the more marked the inhibition.

KEYWORDS : *Digestive work ; Intragastric pH and temperature; Mild and heavy exercise*

Introduction

The effect of physical exercise on the gastric function has been studied by radiographical observations of peristalsis and also by analyses of gastric juice aspired with a cannula, and the gastric function after food intake has been considered to be usually inhibited by physical exercise (Adams et al., 1932 ; Hammar and Öbrink, 1953 ; Lamb, 1978). The authors intended to study the effect of exercise on gastric function by means of a digestive tract capsule, because the determinations of some variances of gastric function by means of transistor radio-capsule swallowed into the stomach can be made without giving constraint to

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the subject and makes possible to get continuous informations of gastric function in physiological state. The main purpose of the study was to observe the changes in gastric juice secretion due to exercise.

Method

Determinations of pH and temperature were made with a telemetering system and signals from a 18.4mm×7.9mm rubber capsule containing Sb electrode (for pH), thermistor (for temperature) and electricity source, which was swallowed into the stomach, and informations were received by a loop antenna worn around the trunk of the subject (Kristensen, 1965) as seen Figure 1. Besides, continuous observations of heart rate, respiration rate and rectal temperature were also carried out during exercise.

As the subjects of the experiment served 5 healthy men whose age ranged from 20 to 33 years. The exercise imposed on the subjects was 5 minute treadmill walking or running. The inclination of the treadmill was 8.6% and three different work loads were imposed on each

Fig. 1. Procedure of determination of intragastric pH and temperature during treadmill exercise. The subject wears a loop antenna around his trunk.

subject, namely, walking at 80m/min (mild exercise), running at 160m/min (moderate exercise) and running at 180 m/min (heavy exercise).

The experiments were generally conducted 16–18 hours after the last meal. It was ascertained in advance that the capsule stayed longer than 80 minutes in the stomach after swallowing (Masuda et al., 1970).

Results

The intragastric pH at rest was 1.56±0.13 on the average (ranging 1.2−1.7) in postabsorptive state, and 2.38±0.66 on the average (ranging 1.5−3.5) 1 hour after having 200 g beefsteak. The temperature of gastric juice at rest was 37.26±0.24°C on the average in postabsorptive state.

In case of mild exercise, where the heart rate reached 100 beats/min, the respiration rate reached 28 times/min and the rectal temperature was kept almost unchanged, the intragastric pH showed increase of about 10−20 % as seen in Figure 2, viz., from 1.4 at rest to 1.7 at the maximum and recovered the initial level in less than 3 min after exercise. However, the intragastric temperature was kept almost unchanged.

In case of moderate exercise, resulting in 166 beats/min of heart rate, 42 times/min of respiration rate, and 0.3−0.4°C rise in rectal as well as oral temperature, the intragastric pH showed increase of about 25 % as seen in Figure 3, viz., from 1.2 at rest to 1.6 at the maximum, but recovered rapidly the initial level after exercise, while the intragastric temperature showed 0.3−0.4°C increase. In case of heavy exercise, resulting in 173−185 beats/min of heart rate, 43−48 times/min of respiration rate, and 0.5−0.6°C rise in rectal temperature at the maximum, the intragastric pH showed increase exceeding 30 % as seen in

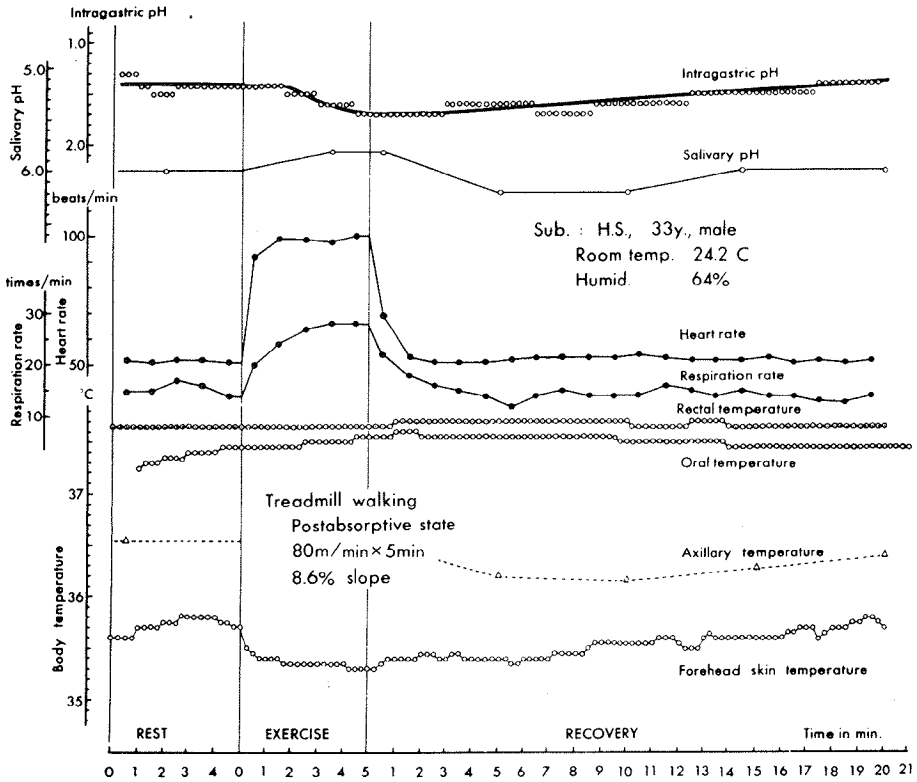

Fig. 2. Changes in the intragastric pH due to mild treadmill exercise in the postabsorptive state.

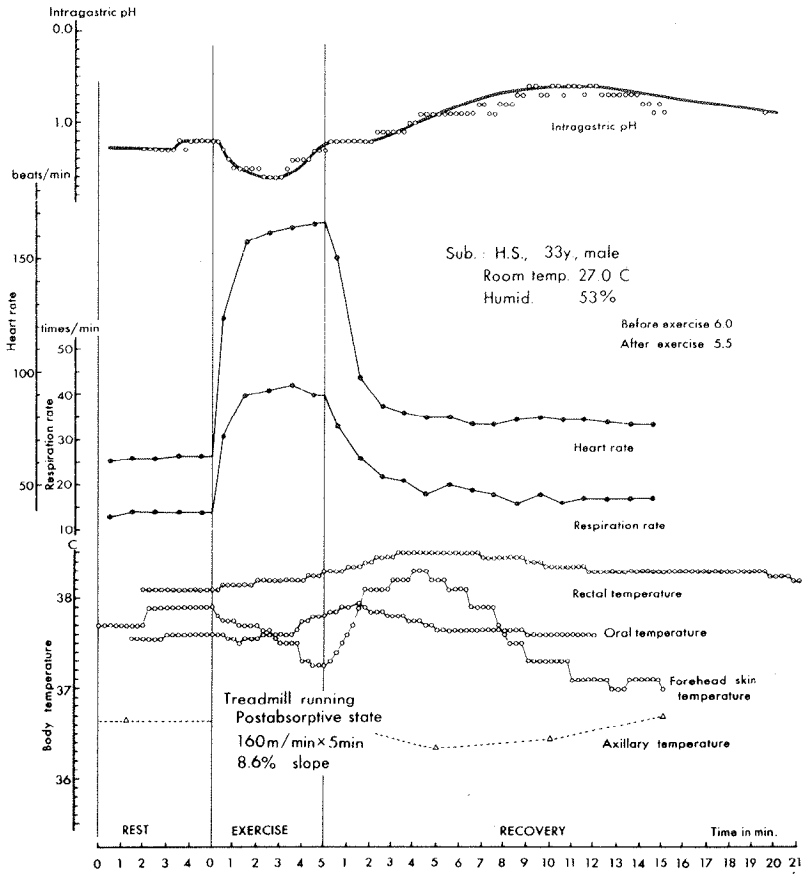

Fig. 3. Changes in the intragastric pH due to moderate treadmill exercise in the postabsorptive state.

Figure 4, viz., from 1.6 at rest to 2.0 at the maximum. Then the intragastric temperature showed 0.9–1.5°C rise as seen in Figure 5. However, the authors investigated the relation between the peak heart rate which was the index of exercise intensity, and the peak value of intragastric pH, there was found no significant correlation.

On the basis of these findings, the authors intended further to investigate the effect of having 200 g beefsteak on the intragastric pH changes due to exercise. In case of heavy exercise 1 hour after having beefsteak, the intragastric pH declined from 1.8 at rest to 0.9 during the exercise as seen in Figure 6, and turned to a rise thereafter to exceed the resting level at the end of exercise. In short, the changes in intragastric pH due to exercise after having beefsteak showed generally a tendency of S-form change, viz., an initial decline followed by a rise. However, the amplitude of change expressed by the percentage of the lowest value or the decrement from the resting level was not in significant relation with the intensity of exercise.

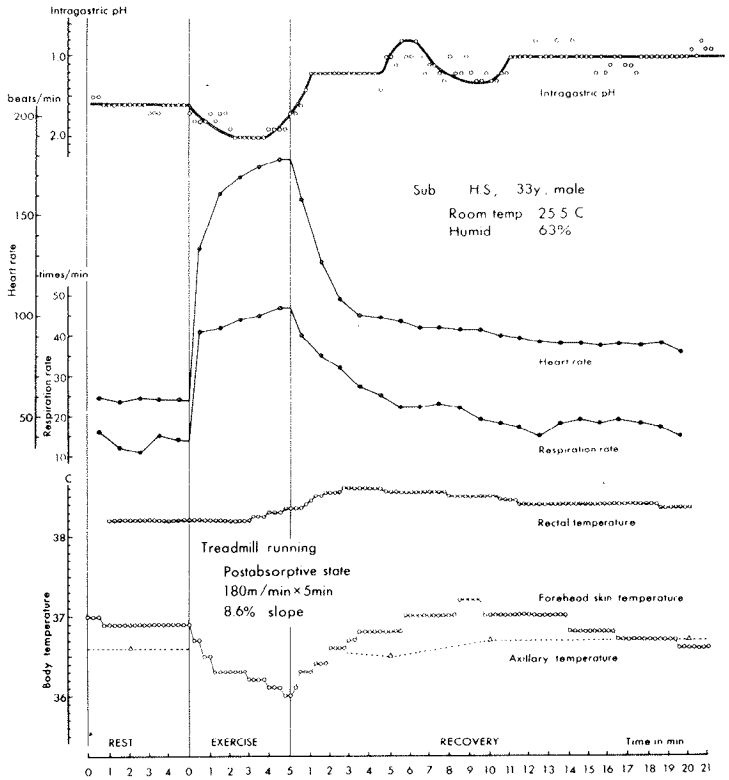

Fig. 4. Changes in the intragastric pH due to heavy treadmill exercise in the postabsorptive state.

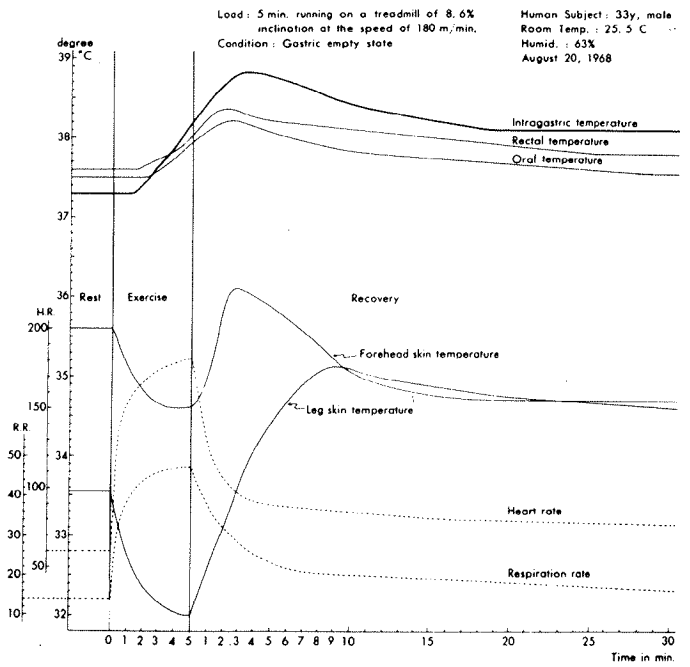

Fig. 5. Changes in intragastric and other body temperatures due to treadmill exercise in the postabsorptive state.

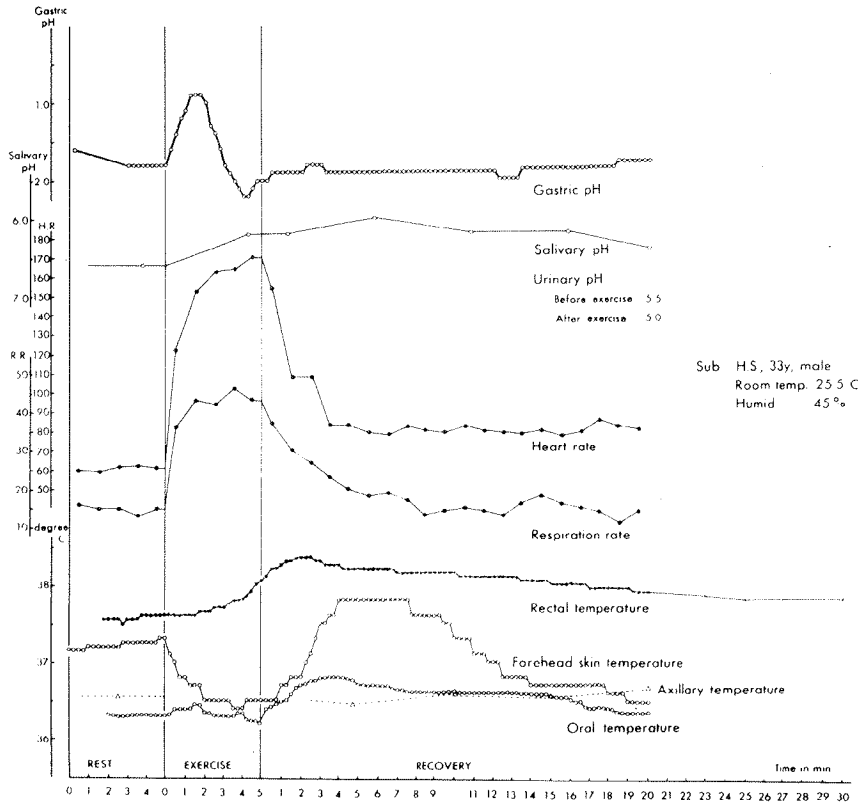

Fig. 6. Changes in the intragastric pH due to heavy treadmill exercise afer having 200g of meat.

Discussion

The energy source for physical exercise is provided with nutrients of food absorbed after digestion, and the digestion is accomplished by the harmony of the digestive tract, the secretion of digestive juice and its fermentative action. Regarding the regulation of gastric juice secretion, two ways are known, namely the neural one owing to conditioned reflex or taste stimulus and the humoral one owing to chemical stimulus of food to the mucous membrane of the stomach (Weisbrodt, 1980). As for the neural regulation, vagotony accelerates the secretion, while sympatheticotony, occurring usually during exercise, inhibits it (Hellebrandt and Tepper, 1934 ; Hellebrandt and Dimmitt, 1934 ; Stock, 1980).

As above-mentioned, it was observed in the present study that the intragastric pH was raised by exercise even when the exercise was mild or heavy. That means the decline of intragastric acidity due to exercise. The finding as such coincides with the conventional knowledge that the physical exercise related with sympatheticotony suppresses the digestive action of the stomach, such as secretion of hydrochloric acid. But, it is needed to study further, as Hammar and Öbrink (1953) pointed out, whether the suppression gets more stronger according to the intensity of exercise or not.

In the results of the present study, the authors could find no significant correlation

between the intragastric pH and the exercise heart rate, as a reliable index of exercise intensity, in case of the experiment in potsabsorptive state.

However, in the experiment after having 200 g beefsteak, which promoted the secretion of gastric juice as a chemical stimulus, the intragastric pH declined during exercise. Therefore, it seemed that the exercise in such case would promote the secretion of hydrochloric acid to lower the intragastric pH and would give effect on protein resolution (Shibayama and Ebashi, 1981). The finding as such suggests that the physical exercise results in the promotion of gastric function as a part of whole body functions, and when the promotion of the functions reaches the steady state after 3–4 min exercise, the redistribution of peripheral blood circulation to meet the oxygen requirement of active muscles and so on causes the decline of gastric secretion of hydrochloric acid, due to decrease of visceral blood circulation.

Therefore, it is presumed that the digestive action in the stomach after having food such as beefsteak would be accelerated in the first stage of exercise, but the hydrochloric acid secretion would diminishes after some minutes exercise. It is presumed that the digestive action in the stomach after having food such as beefsteak is accelerated in the first stage of exercise, but the hydrochloric acid secretion diminishes generally after some minutes of exercise.

胃内 PH および胃内温度におよぼす身体運動の影響

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胃内消化活動におよぼす身体運動の影響を明らかにするために，生理的条件下の胃内 PH および温度を，被検者を無拘束のまま，長時間連続で測定し，身体運動にともなう胃液分泌の推移を観察した。胃内諸量の測定には超小型情報発振器を封入したトランジスタ・カプセルを被検者に飲みこませ，体幹部に装着したループ・アンテナで受信する無線搬送法を用いた。被検者には23～33才の健康な男子５名をえらび，食後16～18時間を経過した空腹時に，軽度，中等度および強度のトレッドミル運動を負荷した。実験に先立ち，胃内カプセルは，飲みこまれたのち，少くとも80分間は胃内に滞留していることを，X 線映画法による撮影記録から確めておいた。

安静時の胃内 PH 値は，空腹時に1.56±0.13を示し，ビフテキ200 g を試験食として摂取させて１時間後では2.38±0.66となった。また胃内温度は直腸温よりやや低く，安静時に37.26±0.24℃を示した。心拍数が100拍/分に増加する軽度の運動では，胃内 PH は10～20％上昇し，胃内温度に変化はみられなかった。また心拍数が173～185拍/分に達するような強度の運動では，胃内 PH は30％以上も上昇し，胃内温度も0.9～1.5℃の増加を示した。しかし運動時の心拍数増加と胃内 PH 上昇，すなわち胃酸分泌減少とのあいだに，意味のある関係を見出すことはできなかった。これらのことから，身体運動は胃内消化活動に抑制的に作用するが，運動強度が高いほど胃液分泌が抑制されるという一義的関係ではないことが確認された。

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