Acta Odontologica Scandinavica. 2014; 72: 424–427

informa healthcare

ORIGINAL ARTICLE

Effect of chewing speed on energy expenditure in healthy subjects

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Abstract

Objective. The aim of the study was to investigate the effect of rate of chewing on energy expenditure in human subjects. ***Materials and methods.*** Fourteen healthy subjects (aged 18–24 years) within the normal range of BMI participated in a cross-over experiment consisting of two 6-min sessions of gum chewing, slow (~60 cycles/min) and fast (~120 cycles/min) chewing. The resting energy expenditure (REE) and during gum chewing was measured using a ventilated hood connected to a gas analyzer system. The normality of data was explored using the Shapiro-Wilk test. The energy expenditure rate during chewing and the energy expenditure per chewing cycle were compared between the two chewing speeds using Wilcoxon signed ranks tests. ***Results.*** The energy expenditure per chewing cycle during slow chewing (median 1.4, range 5.2 cal; mean 2.1±1.6 cal) was significantly higher than that during fast chewing (median 0.9, range 2.2 cal; mean 1.0±0.7 cal) ($p < 0.005$). However, the energy expenditure rate was not significantly different between the two chewing speeds ($p > 0.05$). ***Conclusions.*** The results of this study suggest that chewing at a slower speed could increase the energy expenditure per cycle and might affect the total daily energy expenditure.

Key Words: *low-intensity exercise, chewing speed, mastication, energy expenditure*

Introduction

Chewing is a daily practice often gone unnoticed. Not until recently have researchers paid attention to the benefit of chewing. Studies in mice and rats have confirmed the improvement of memory [1,2] when rats are fed with hard diets that require chewing. It has also been shown that rats fed with soft diet gain more weight compared to those fed with normal diet during a period of 26 weeks [3]. Such weight difference was proposed to be related to the increased level of neuronal histamine from the tuberomammillary nucleus (TMN) in the hypothalamus as a result of chewing. The mechanism is believed to be mediated through sensory pathways via the mesencephalic nucleus of the trigeminal nerve [4]. Since the act of chewing generally involves forceful and repetitive contraction of jaw closing muscles, it is therefore possible that the less weight gain in rats could also be the result of energy expenditure during chewing. In humans, it has been shown that gum chewing for 12 min at 100 cycles/min can increase the body energy expenditure rate by 11 ± 3 kcal/h or by 19% above resting stage [5]. The effect of chewing speed on fat metabolism may be reflected by a questionnaire survey in Japanese people which showed those who ate quickly had higher energy intake and body mass index than those eating at a normal speed [6]. The study, however, did not state if quick eaters were the ones with fast chewing speed or a small number of chews. Habitual chewing frequency in humans ranges between 76–108 cycles/min [7–9]. We hypothesized that the chewing speed might affect the energy expenditure during the power stroke of a chewing cycle. It was the purpose of the present study to investigate the effect of chewing speed on the energy expenditure rate and the expenditure 'per chewing cycle'.

Materials and methods

Subjects

The study was approved by the Ethical Committee for Human Research at Khon Kaen University. Fourteen

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(Received 24 July 2013; accepted 16 September 2013)

ISSN 0001-6357 print/ISSN 1502-3850 online
DOI: 10.3109/00016357.2013.847490

subjects (seven females and seven males, aged 18–24 years) participated in the study. They were healthy, had at least 28 natural teeth (excluding third molars) and did not have any pain in the masticatory system. All subjects gave informed consent before participation.

Procedure

This study is a cross-over design. Each subject randomly underwent two gum-chewing sessions, slow and fast chewing. On arrival of each visit, each subject lay down on a firm, flat bed in a quiet, air conditioned room (at 25°C). The subject was asked to rest for 30 min. Near the end of the resting period, the subject was asked to lightly hold a piece of sugar-free chewing gum (Trident, Cadbury Adams Thailand, Bangkok, Thailand) between the upper and lower lips. A clear plastic hood, connected to a gas analyzer system (Vmax22, Sensor medic, the Netherlands), was then placed over the head. The expired air during the first 6 min was analyzed for the 'resting' energy expenditure rate (REE, kcal/min). Thereafter, the metronome was turned on for 1 min. After the metronome had stopped, the subject was asked to chew the gum for 6 min at the speed as close as possible to the frequency of the metronome just heard (either 60 cycles/min for slow or 120 cycles/min for fast chewing). The first chewing rate to be tested was randomly chosen. Throughout the 6-min gum chewing session, the expired air was again analyzed. The subject was allowed to rest for 30 min before performing another session with the second chewing speed. The number of chews was counted using a hand tally counter.

Data analysis

The chewing rate was derived from the number of chews during the 6-min chewing session. Both the energy expenditure rate during chewing (the difference between the expenditure rate during the chewing session and REE) and the energy expenditure 'per chewing cycle' were compared between the two chewing speeds. Since the data were not normally distributed (explored by Shapiro-Wilk test), all comparisons were investigated using Wilcoxon signed ranks tests. A significant difference was determined if p-Value is less than 0.05.

Results

All subjects were healthy and had normal energy balance according to their normal range of body mass index (BMI). Their mean (SD) height, weight and BMI of subjects were 169.2 (7.9) cm,59.6 (12.6) kg and 20.6 (2.9) kg/m^2, respectively. Subjects were able to chew at speeds well close to the metronome without any complaint of pain. The mean (SD) chewing rate during slow chewing was 56.2 (3.9) cycles/min and that during fast chewing was 114.1 (15.2) cycles/min. The median (range) REE before the slow chewing session was 0.86 (0.49) kcal/min, whereas that before the fast chewing session was 0.87 (0.75) kcal/min without any significant difference (p = 0.187) (Figure 1A). The median energy expenditure rate was significantly increased in both slow [0.08 (0.22) kcal/min] and fast chewing [0.10 (0.29) kcal/min] (p = 0.001) without any significant difference between the two chewing speeds (p = 1.000; Figure 1B). On the contrary, when the energy expenditure 'per cycle' was compared, the median energy expenditure during slow chewing [1.4 (5.2) cal/cycle; mean 2.1±1.6] was significantly higher than that during fast chewing [0.9 (2.2) cal/cycle; mean 1.0±0.7] (p = 0.004) (Figure 1C).

Discussion

The present study has demonstrated the effect of chewing speed on the energy expenditure in humans. It was shown that chewing at ~60 cycles/min resulted in greater energy expenditure 'per cycle' than at ~120 cycles/min. However, no significant difference in the total expenditure rate was found, given the same period of chewing time. The energy expenditure per cycle tended to be proportionally inverse to the speed of chewing; a mean value of ~2 cal was burnt during slow chewing, whereas ~1 cal was burnt during fast chewing. This suggested that chewing speed might directly affect the motor aspect of a chewing stroke, due to smaller vertical, lateral and antero-posterior movements and a shorter occlusal phase during fast than slow chewing [10,11]. This would shorten the contraction time of jaw muscles and, hence, reduce the energy expenditure. In addition, the occlusal force during slow chewing is presumably larger than that during fast chewing. This is indirectly supported by the finding that chewing food at 40 cycles/min results in finer median particle size than at 100 cycles/min [12].

The increase in energy expenditure during chewing in this study is comparable to that found by a previous study. Levine et al. [5] have shown an increase of 11 ± 3 kcal/h energy expenditure or by 19% above resting stage during 12-min gum chewing at the speed of 100 cycles/min. An average increase of ~13% during 6-min gum chewing was found in the present study. The actual energy expenditure during habitual chewing is likely to differ from the above values since the chewing frequency [9] and food texture during a real meal are different from those during the experimental gum chewing in this study.

Women took averages of 51 mouthfuls and 15 chews/mouthful during a pre-cooked chicken and vegetables pieces meal [9]. If the previous data

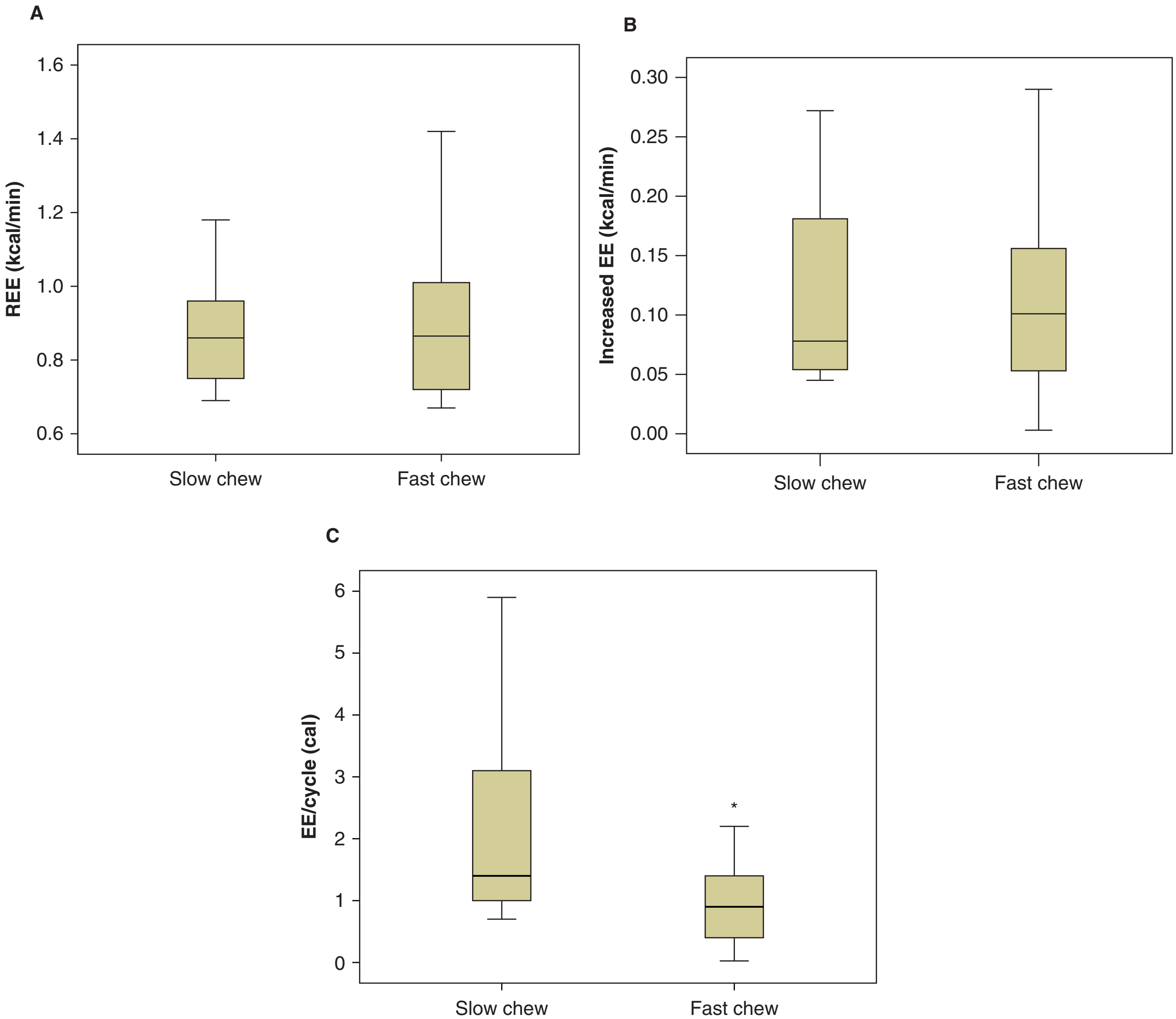

Figure 1. Box plots comparing (A) 'resting' energy expenditure rate (REE), (B) 'increased' energy expenditure rate, (C) energy expenditure 'per chewing cycle', during slow and fast gum chewing. * Significant difference, $p < 0.005$.

were used, it could be estimated that a person could perform ~2300 chewing cycles by eating three meals daily. The total calories burnt from chewing in a person who chews at 60 cycles/min could reach ~4.6 kcal per day (based on the above value of 2 cal/cycle). The amount might seem insignificant, but its cumulative effect should not be underestimated since chewing also occurs between meals or during gum chewing. Taking all above into account, the energy expenditure from chewing could be summed up to ~150 kcal a month, which is approximately equivalent to three 20-min sessions of walking at 2 mph [13].

Fast eating behavior has been shown to be associated with overweight [6,14]. However, it is possible that fast eaters are also fast chewers, those who chew less, or those who consume more food during a meal, all of which could contribute to the risk of the overweight among these persons. Therefore, the effect of chewing speed on body weight (if any) should be interpreted with caution.

Conclusions

Under the conditions used in the present study, it is concluded that chewing at a slower speed could increase the energy expenditure per chewing cycle and might affect the total daily energy expenditure.

Acknowledgments

The authors would like to thank Professor Ian A. Macdonald for valuable comments on the original version of the manuscript and Ms Jatuporn Wichitsranoi for her good laboratory assistance. The authors would also like to thank all subjects for their kind participation. The research was supported by a research grant at the Faculty of Dentistry, Khon Kaen University.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

[1] Aoki H, Kimoto K, Hori N, Toyoda M. Cell proliferation in the dentate gyrus of rat hippocampus is inhibited by soft diet feeding. Gerontol 2005;51:369–74.
[2] Onozuka M, Watanabe K, Mirbod SM, Ozono S, Nishiyama K, Karasawa N, et al. Reduced mastication stimulates impairment of spatial memory and degeneration of hippocampal neurons in aged SAMP8 mice. Brain Res 1999; 826:148–53.
[3] Oka K, Sakuarae A, Fujise T, Yoshimatsu H, Sakata T, Nakata M. Food texture differences affect energy metabolism in rats. J Dent Res 2003;82:491–4.
[4] Sakata T, Yoshimatsu H, Masaki T, Tsuda K. Anti-obesity actions of mastication driven by histamine neurons in rats. Exp Biol Med (Maywood) 2003;228:1106–10.
[5] Levine J, Baukol P, Pavlidis I. The energy expended in chewing gum. N Engl J Med 1999;341:2100.
[6] Maruyama K, Sato S, Ohira T, Maeda K, Noda H, Kubota Y, et al. The joint impact on being overweight of self-reported behaviours of eating quickly and eating until full: cross sectional survey. BMJ 2008;337:a2002.
[7] Bellisle F, Guy-Grand B, Le Magnen J. Chewing and swallowing as indices of the stimulation to eat during meals in humans: effects revealed by the edogram method and video recordings. Neurosci Biobehav Rev 2000;24: 223–8.
[8] de Castro JM, Bellisle F, Dalix AM, Pearcey SM. Palatability and intake relationships in free-living humans. Characterization and independence of influence in North Americans. Physiol Behav 2000;70:343–50.
[9] Ioakimidis I, Zandian M, Eriksson-Marklund L, Bergh C, Grigoriadis A, Sodersten P. Description of chewing and food intake over the course of a meal. Physiol Behav 2011; 104:761–9.
[10] Throckmorton GS, Buschang BH, Hayasaki H, Phelan T. The effects of chewing rates on mandibular kinematics. J Oral Rehabil 2001;28:328–34.
[11] Plesh O, Bishop B, McCall W. Mandibular movements and jaw muscles' activity while voluntarily chewing at different rates. Exp Neurol 1987;98:285–300.
[12] Buschang PH, Throckmorton GS, Travers KH, Johnson G. The effects of bolus size and chewing rate on masticatory performance with artificial test foods. J Oral Rehabil 1997;24: 522–6.
[13] Passmore R, Durnin JV. Human energy expenditure. Physiol Rev 1955;35:801–40.
[14] Lin M, Pan L, Tang L, Jiang J, Wang Y, Jin R. Association of eating speed and energy intake of main meals with overweight in Chinese pre-school children. Public Health Nutr 2013. doi: 10.1017/S1368980013002176. Epub adhead of print.