Doctoral Thesis

A Quantitative Assessment Methodology of Pharyngeal Swallow

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by

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ABSTRACT

Dysphagia is the disorder related to difficulty in swallowing and is more frequently observed among patients with neurologic diseases such as stroke or people aged 65 and over. Undiagnosed or untreated dysphagia may lead to aspiration, pneumonia, dehydration, malnutrition, or even asphyxiation and death; therefore, early identification and appropriate treatment of dysphagia are important. Dysphagia has been mainly diagnosed by videofluoroscopic swallowing study (VFSS) and fiberoptic endoscopic evaluation of swallowing (FEES); but, both VFSS and FEES have limitations in terms of qualitative analysis and low safety (VFSS: radiation, FEES: invasion). The precedent study (Lee et al., 2012) developed a swallowing measurement device employing ultrasonic Doppler to measure a pharyngeal movement during swallowing. As a follow-up study, quantification, analysis, and interpretation of the measured pharyngeal swallowing signal and specialization for diagnosis of dysphagia are needed.

The objective of the present study is to develop a quantitative assessment methodology of pharyngeal swallow. The specific objectives are as follows: (1) screening of swallowing out of pharyngeal movement signals, (2) establishment of a swallowing quantification protocol, (3) interpretation of pharyngeal movement signal by interoperating with VFSS video, (4) comparison of pharyngeal movement between healthy adults and dysphagic patients, and (5) development of a diagnostic model for discriminating the severity of dysphagia.

First, a swallowing screening algorithm was developed to extract swallowing movements only out of various pharyngeal movements such as cough and vocalization measured by ultrasonic Doppler. Utilizing a concept of swallowing apnea that vocalization is impossible during pharyngeal swallow, a microphone for measuring audio signals was interoperated with the ultrasonic Doppler sensor. Signal processing techniques (e.g., moving average) and statistical methods (e.g., maximum-likelihood function) were also incorporated into the swallowing screening algorithm. As a result, the swallowing movement was completely discriminated from cough and vocalization that are also involved with pharyngeal movement.

Second, to represent the characteristics of the pharyngeal movement during swallowing, the present study proposed five quantitative measures such as peak amplitude, duration time, number of peaks, peak-to-peak interval, and impulse by applying the four-step swallowing signal processing technique (S1. rectification, S2. smoothing, S3. peak detection, and S4. starting/ending points detection). A program that automatically calculates aforementioned five measures for a given swallowing signal was also developed.

Third, pharyngeal movement signals were interpreted by interoperating with the corresponding VFSS video. The majority of pharyngeal movement signals showed two peaks, and 1^{st} and 2^{nd} peaks indicates ascending and descending movements of the laryngopharynx during swallowing, respectively. Based on VFSS video analysis, five measures of swallowing movement were interpreted as follows: peak amplitude – maximum instant movement of the laryngopharynx; duration time – total movement time in the laryngopharynx; number of peaks – number of movement changes in the laryngopharynx; peak-to-peak interval – bolus transportation time in the pharyngeal stage; and impulse – total movement of the laryngopharynx.

Fourth, swallowing characteristics of healthy adults and dysphagic patients were analyzed by swallowing experiment. Swallowing signals for dry saliva, thin liquid 1, 3, 9 ml, thick liquid 1, 3, 9 ml were acquired from 120 healthy adults and

36 dysphagic patients. The swallowing signals from 88% of healthy adults showed one peak (49%) or two peaks (39%). Healthy adults were categorized as short-double peak (duration < 1 s and # peaks = 2; 43%), short-single peak (< 1 s and 1; 39%), and short-multiple peak (< 1 s and ≥ 3; 18%); dysphagic patients as short-double peak (< 1 s and 2; 58%), long-double peak (≥ 1 s and 2; 33%), and long-multiple peak (≥ 1 s and ≥ 3; 9%). Gender (F:M = 1:0.8), swallowing type (thick:thin = 1:1.2), and volume (1:3:9 ml = 1:1.1:1.3) were found significant on highest peak amplitude; swallowing type (thick:thin = 1:1.4) and volume (1:3:9 ml = 1:1.1:1.3) on impulse. Peak amplitude of dysphagic patients was 0.7 times lower compared with that of healthy adults; duration time 2.6 times longer; number of peaks 1.7 times higher; peak-to-peak interval 4.3 times longer; and impulse 0.8 times lower.

Lastly, diagnostic models for discriminating the severity of dysphagia into normal, mild, and moderate/severe were developed. Five cumulative *logit* models for swallowing dry saliva, thin liquid 1 ml, 3 ml, thick liquid 1 ml, and 3 ml were developed using swallowing data of 120 healthy adults (normal) and 31 dysphagic patients (mild for 18 and moderate/severe for 13). The cumulative *logit* model for swallowing thin liquid 1 ml (input variables: age, gender, duration time, number of peaks, longest peak-to-peak interval, and impulse; sensitivity for mild = 50%, sensitivity for moderate/severe = 92%, specificity = 100%, and accuracy = 81%) was selected as the best model in terms of discriminant performances and practicality in clinics.

The quantitative assessment methodology of the laryngopharyngeal movement during swallowing developed in the present study can contribute to real-time, accurate, and effective evaluation of the pharyngeal swallow. The swallowing analyses results of the laryngopharyngeal movement of healthy adults and dysphagic patients and the diagnostic model for discriminating the severity of dysphagia are readily applicable to medical diagnosis of dysphagia with VFSS in clinics.

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Chapter 1 INTRODUCTION

1.1. Problem Statement

Dysphagia is the disorder related to difficulty in swallowing and its prevalence is mainly higher among patients with neurologic diseases such as stroke and people more than 65 years. Swallowing (called deglutition) is the process that makes something pass from the mouth, to the pharynx, and into the esophagus, while shutting the epiglottis (Ekberg, Hamdy, Woisard, Wuttge-Hannig, & Ortega, 2002) and belongs to the most frequent activities in the human body: the human being swallows between 580 ~ 2,000 times a day (Garliner, 1974; Logemann, 1983, 1998). Dysphagia refers to the swallowing disorder which interferes with a patient's ability to intake or transport food from the oral cavity to the stomach Leopold and Kagel (1996). Most patients with neurologic disease accompany dysphagia as shown in Table 1.1 summarized by Daniels (2006). For example, Daniels et al. (1998) reported that 65% of patients with stroke were accompanied with dysphagia. Meanwhile, the prevalence of dysphagia among adults aged 65 years and above are 11% to 38% as shown in Table 1.2 (Holland et al., 2011; Kawashima, Motohashi, & Fujishima, 2004; Miura, Kariyasu, Yamasaki, & Arai, 2007; Roy, Stemple, Merrill, & Thomas, 2007; Stewart, Hurd, Logemann, Aschman, & Matthews, 2011). For example, Miura et al. (2007) revealed that the prevalence of dysphagia 85 adults more than 65 years (81 ± 7 years) in Japan was 35.3% by self- and caregivers- assessment for screening dysphagia.

Table 1.1. Prevalence of dysphagia by neurologic diseases (Daniels, 2006)

No.	Neurologic disease	Studies (year)	Dysphagia prevalence
1	Amyotrophic lateral sclerosis	Kawai et al. (2003)	100%
2	Huntington's disease	Edmonds (1966)	85%
3	Alzheimer's disease	Horner et al. (1994) Volicer et al. (1989)	84% 32%
4	Progressive supranuclear palsy	Litvan et al. (1996)	later stage: 83% early stage: 16%
5	Olivopontocerebellar atrophy	Schut (1950) Landis et al. (1974)	75% 44%
6	Stroke	Daniels et al. (1998)	65%
7	Parkinson's disease	Fuh et al. (1997) Lieberman et al. (1980)	63% 50%
8	Traumatic brain injury	Mackay et al. (1999) Winstein (1983)	61% 25%
9	Cervical spine surgery	Smith-Hammond et al. (2004)	50%
10	Carotid endarterectomy	Ekberg et al. (1989) AbuRahama and Lim (1996)	42% 3%
11	Multiple sclerosis	Calcagno et al. (2002)	34%
12	Frontotemporal dementia	Ikeda et al. (2002)	30%

Table 1.2. Prevalence of dysphagia among people more than 65 years

No.	Studies (year)	Age	Participants	Dysphagia assessment method	Dysphagia prevalence
1	Stewart et al. (2011)	69 – 98 (M: 81)	161 adults in the world	Modified Barium Swallow (MBS)	10.6%
2	Holland et al. (2011)	69 – 98 (M: 81)	634 adults in England	Swallow questionnaire (self-report)	11.4%
3	Kawashima et al. (2004)	> 65 (74 ± 7)	1,313 adults in Japan	Swallow questionnaire (self-report)	13.8%
4	Miura et al. (2007)	> 65 (81 ± 7)	85 adults in Japan	Self- and caregivers-assessment	35.3%
5	Roy et al. (2007)	> 65 (76 ± 9)	117 adults in USA	Interview	38.0%

Early identification and appropriate treatment of dysphagia are important. Some dysphagic patients have limited awareness of their dysphagia and undiagnosed or untreated dysphagia may lead to aspiration, pneumonia, dehydration, malnutrition (see Figure 1.1), or even asphyxiation and death (Ekberg et al., 2002). For example, aspiration pneumonia, which occurs when food, saliva, liquids, or vomit is breathed into the lungs or airways leaning to the lungs caused by an incompetent swallowing mechanism, is the fourth cause of death (1st: cancel, 2nd: cerebrovascular diseases, 3rd: cardiovascular disease) among adults more than 65 years (Sasaki, 1991). In addition, every year, about 50,000 Americans die from pulmonary complications of aspiration by dysphagia (Jones & Donner, 1991). Therefore, the medical profession has considered with accurate diagnosis, prompt treatment, and steady management of patients with dysphagia (Wilkins, Gillies, Thomas, & Wagner, 2007).

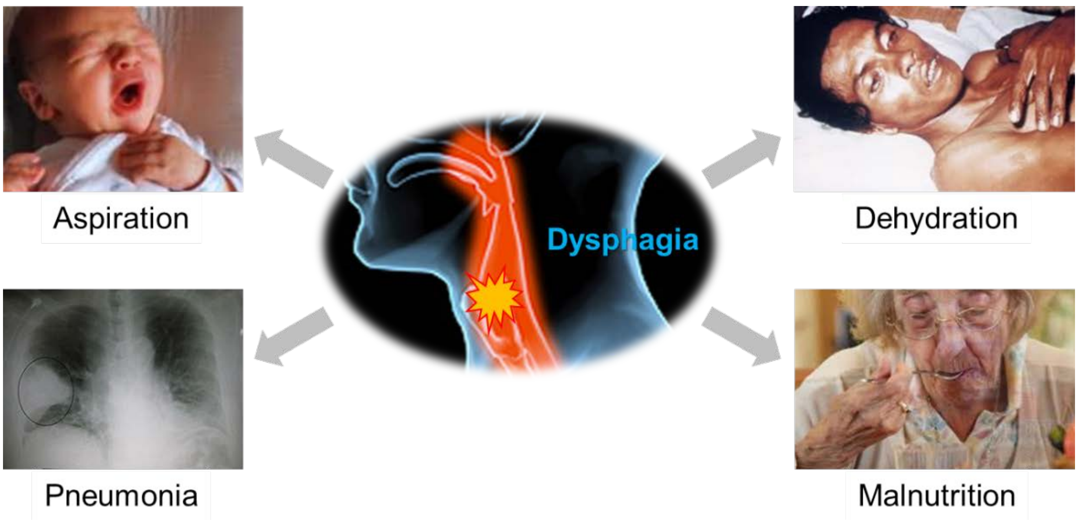


Figure 1.1. Major symptoms of dysphagia

The pharyngeal swallow limited to be observed during swallowing can be measured by specialized instrument evaluation tools. Anatomically, the normal swallow is divided into three phases as shown in Figure 1.2: oral, pharyngeal, and esophagus phases (Brühlmann, 1985; Dodds 1989; Ekberg & Wahlgren, 1985; Hannig & Hannig, 1987; Pokieser, Schober, & Schima, 1995). In the oral phase, the bolus formed by suckling, chewing, and masticating food is passed into the pharynx. In the pharyngeal phase, the bolus is passed into the esophagus by the close temporal activation such as soft palate elevation, hyo-laryngeal excursion, and pharyngeal peristalsis. Lastly, in the esophagus phase, the bolus is passed into the stomach by esophageal peristalsis. The oral stage of dysphagia can be diagnosed by visual inspection; however, the pharyngeal and esophagus stages of dysphagia are limited to be observed due to their anatomical structures. Therefore, specialized equipment such as diagnostic X-ray (radiograph) system have been utilized to examine the pharyngeal and esophagus stages of dysphagia more accurately.

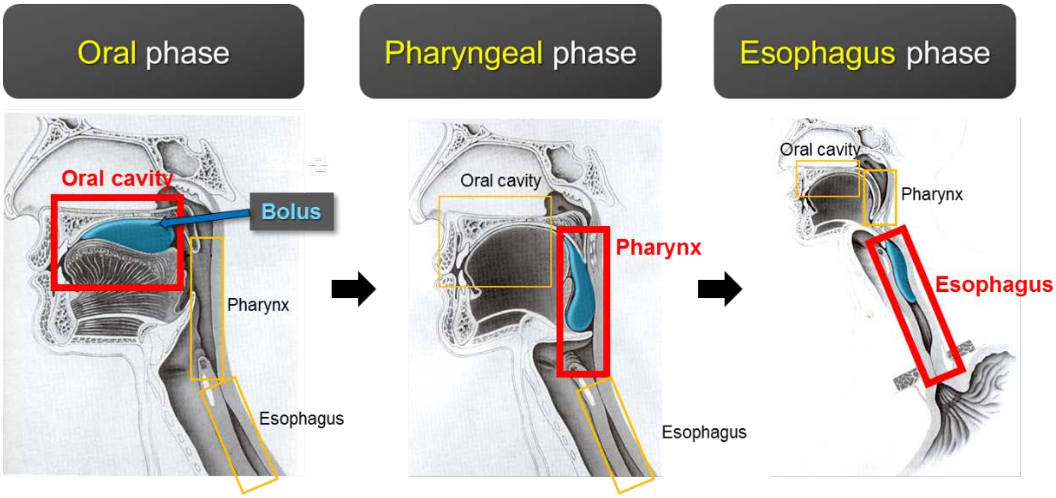
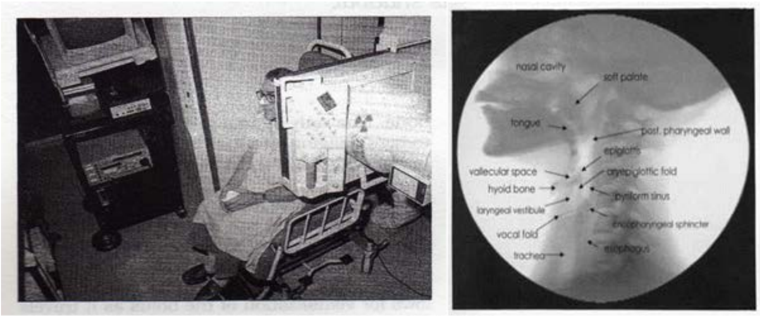


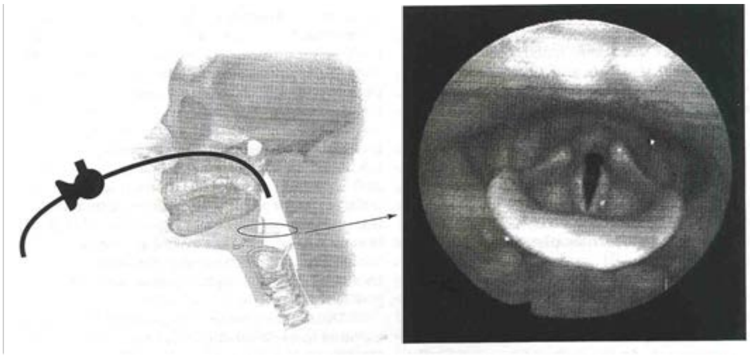
Figure 1.2. Normal swallow phases

Dysphagia has been mainly diagnosed by videofluoroscopic swallowing study (VFSS) and fiberoptic endoscopic evaluation of swallowing (FEES); but, both VFSS and FEES have limitations in terms of low safety and usability. VFSS (see Figure 1.3a) is a diagnostic procedure that allows clinicians to examine swallowing functions using fluoroscopic video recorded by a special movie-type X-ray; FEES (see Figure 1.3b) to evaluate conditions before and after swallowing through entering a flexible endoscope into the nose (Langmore et al., 1988). However, in VFSS, clinicians conduct a qualitative, not quantitative, examination for swallowing by observing anatomical structures; patients have health concerns due to radiation exposure. In FEES, clinicians have difficulties in observing swallowing functions during swallowing; patients may be uncomfortable due to invasiveness, introducing a flexible fiberoptic endoscope transnasally. In common, VFSS and FEES are limited due to expensive price, general-purpose, difficulty in monitoring swallowing in daily activities, and difficulty to evaluate the effectiveness of dysphagia therapy at the proper time (Lee, Lee, et al., 2012). Therefore, to improve the aforementioned limitations of VFSS and FEES, a specialized method and device for evaluation of swallowing is needed to identify dysphagia in quantitative and safe manner.

A new device using ultrasonic Doppler sensors has been developed to examine swallowing functions in the previous study and is additionally needed to specialize in evaluating dysphagia through quantification of swallowing signal measured by ultrasonic Doppler during swallowing. The precedent study (Lee, Jung, et al., 2012) developed a swallowing measurement system (SMS) to acquire movement signals of the laryngopharynx, which is the caudal part of the pharynx, for evaluation of the pharyngeal



(a) Videofluorocopic swallowing study (VFSS)



(b) Fiberoptic endoscopic evaluation of swallowing (FEES)

Figure 1.3. Typical evaluation methods of dysphagia

stage of dysphagia (see Figure 1.4). The SMS measures the movement of coordination among internal organs of the laryngopharynx during swallowing by attaching the ultrasonic Doppler sensor, which is harmless to humans, using a flexible band outside the neck. To improve applicability of the SMS to clinical diagnosis of dysphagia, an in-depth study is needed to conduct following topics: quantification, interpretation, and analysis of the swallowing signal and development of a diagnostic model for dysphagia.

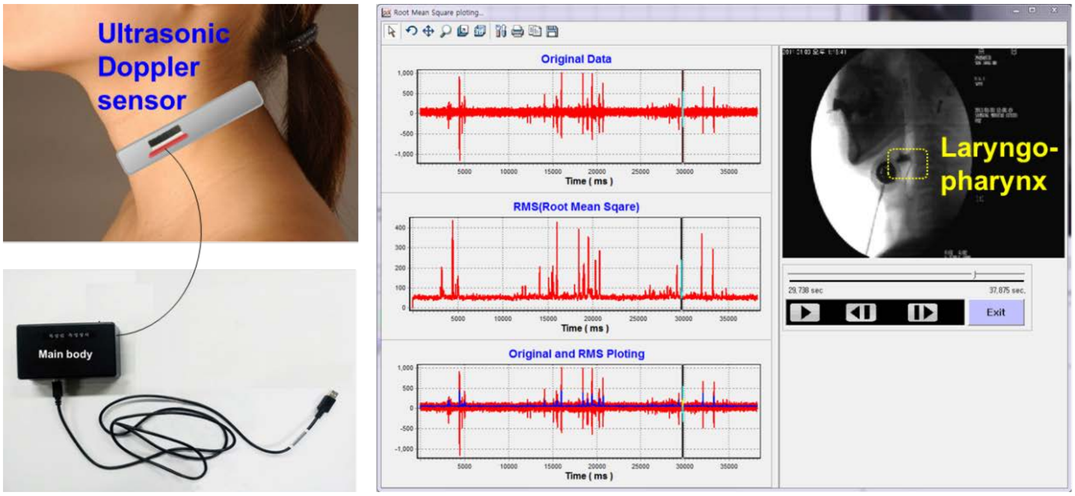


Figure 1.4. Swallowing measurement system (Lee, Jung, et al., 2012)

1.2. Objectives of the Study

The present study is to achieve five specific objectives as following: (1) screening of the swallowing signal out of ultrasonic Doppler signals, (2) quantification of the swallowing signal, (3) interpretation of the swallowing signal by interoperating with the laryngopharynx motion during swallowing, (4) comparison of swallowing characteristics between healthy people and patients with dysphagia, and (5) development of a diagnostic model for dysphagia.

First, the present study is to develop an algorithm for screening swallowing activities out of various laryngopharynx movement-related activities measured by ultrasonic Doppler. Characteristics of the swallowing activity are distinguished compared to those of other activities (e.g., cough). A swallowing screening algorithm including smoothing and filtering techniques is developed based on the laryngopharyngeal protective mechanism.

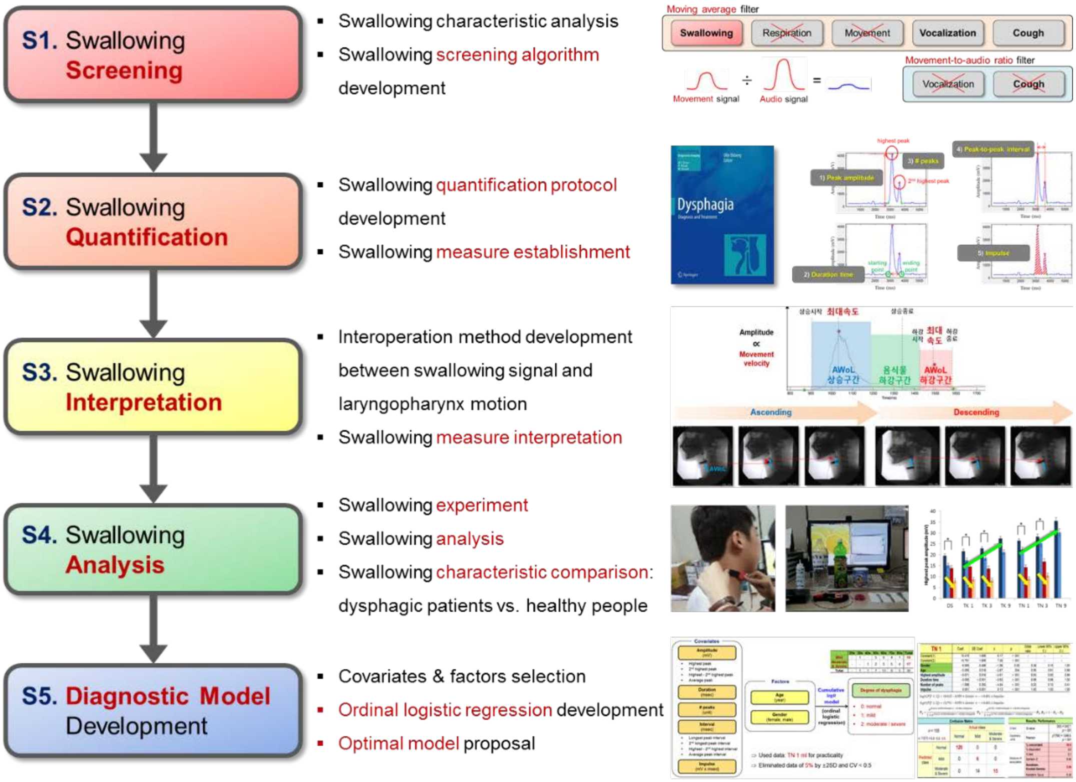


Figure 1.5. Research framework

Second, the present study is to develop a signal processing technique for the swallowing signal and establish swallowing measures to quantify the swallowing activity. A quantification protocol of swallowing is developed to identify characteristics of swallowing by using the swallowing signal measured by ultrasonic Doppler during swallowing. Swallowing measures (e.g., swallowing duration) are extracted from the swallowing signal by development of a swallowing automatic quantification program.

Third, the present study is to interpret the swallowing signal by interoperating with VFSS video recorded during swallowing. Meanings by reference point such as starting/ending points and peak on the swallowing signal are apprehended through real-time synchronization of the VFSS video and the swallowing signal measured during swallowing. The swallowing measures are interpreted based on the meaning of the swallowing signal with experts of dysphagia.

Forth, the present study is to compare patients with dysphagia with healthy people in terms of the swallowing measures by conducting a swallowing experiment. A swallowing experiment is conducted for participants to swallow saliva, thin liquid 1, 3, 9 ml, and thick liquid 1, 3, 9 ml. Effects of age, gender, swallowing food, and swallowing volume on the swallowing measure are examined. Swallowing characteristics of patients with dysphagia are compared to those of healthy people.

Lastly, the present study is to develop an optimal diagnostic model for dysphagia to classify a dysphagia severity level as normal, mild, moderate, and severe. Input variables of the diagnostic model are selected out of age, gender, and swallowing measures considering their significances on dysphagic severity. An optimal diagnostic model for dysphagia is proposed by comparing various diagnostic models developed by applying the ordinal logistic regression.

1.3. Significance of the Study

The swallowing quantification protocol developed in the present study can be effectively applicable to quantification and analysis of the swallowing activity by applying to the swallowing measurement system using ultrasonic Doppler (Figure 1.6). The

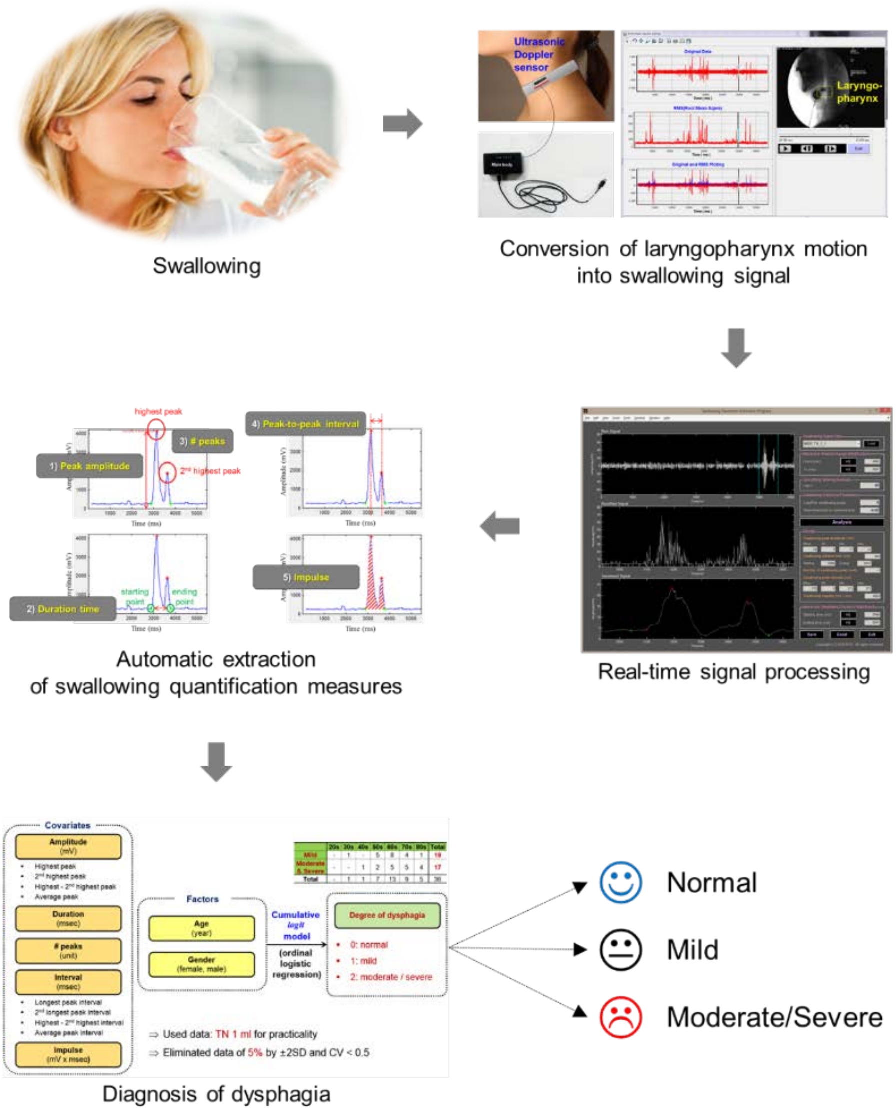


Figure 1.6. Swallowing quantification protocol for the diagnosis of dysphagia

precedent study (Lee, Jung, et al., 2012) developed the swallowing measurement system to measure the coordinating motion among internal organs in the laryngopharynx during swallowing; however, needs to evaluate its effectiveness to apply to the diagnosis of patients with dysphagia. For quantification of swallowing, the present study developed the algorithm for screening only the swallowing activity, the technique for noise reduction, smoothing, and clarification of ultrasonic Doppler signal, and the measure for characterizing the laryngopharynx motion during swallowing. The effectiveness of the swallowing quantification protocol was evaluated by identifying significant differences between swallowing characteristics of patients with dysphagia and those of healthy people in clinical testing about various swallowing (dry saliva; thin liquid 1, 3, 9 ml; thick liquid 1, 3, 9 ml). Dysphagia has been subjectively diagnosed by clinicians through observation of structures and movements of swallowing-related organs during swallowing using VFSS and/or FEES images. Therefore, the swallowing quantification protocol proposed in the present study can contribute to diagnosing swallowing and dysphagia more quantitatively and accurately.

The diagnostic model for dysphagia developed in the present study can be helpful to evaluate the severity of patients with dysphagia (Figure 1.6). The present study found that diagnostic models for evaluating dysphagia/swallowing do not exist based on literature review. Considering practicality in clinics, the diagnostic model for dysphagia automatically evaluates dysphagia using real-time data swallowing saliva or a small quantity of water (e.g., 1 ml). The cumulative *logit* model of ordinal logistic regression was applied in the diagnostic model for dysphagia for discriminating not only the existence of dysphagia but also the severity of dysphagia such as mild, moderate, and severe levels. If the diagnostic model for dysphagia is employed in the swallowing measurement system, the swallowing activity can be quantitatively evaluated in real time. Thus, the diagnostic model for dysphagia can contribute to enhancing accuracy and efficiency of dysphagia evaluation.

The interpretation result of the swallowing signal revealed in the present study can contribute to improving quality of life for patients with dysphagia by applying to the interoperation with a dysphagia therapy using functional electrical stimulation (FES) (Figure 1.7). The present study found the timing on the swallowing signal to stimulate the laryngopharynx during swallowing for solving swallowing difficulties. As shown in Figure 1.7, in the future, a new mobile system for both measurement and therapy of the swallowing activity can be developed as one of solutions to solve dysphagia on real-time in daily life activities (e.g., lunch). Notice that measurement systems such as VFSS and FEES and therapy systems such VitalStim® Therapy System (Empi, Inc., USA) as of swallowing/dysphagia have been separately developed. Therefore, the aforementioned swallowing measurement and therapy system, which provides FES to the laryngopharynx during swallowing based on real-time evaluation of the swallowing activity, can contribute

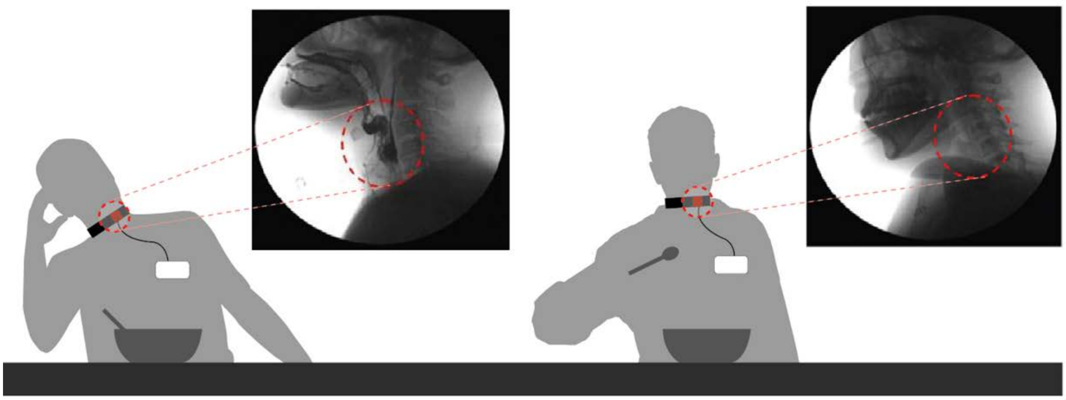


Figure 1.7. Application of the swallowing measurement and therapy device

to improving quality of life and reducing deaths due to aspiration for patients with dysphagia.

1.4. Organization of the Dissertation

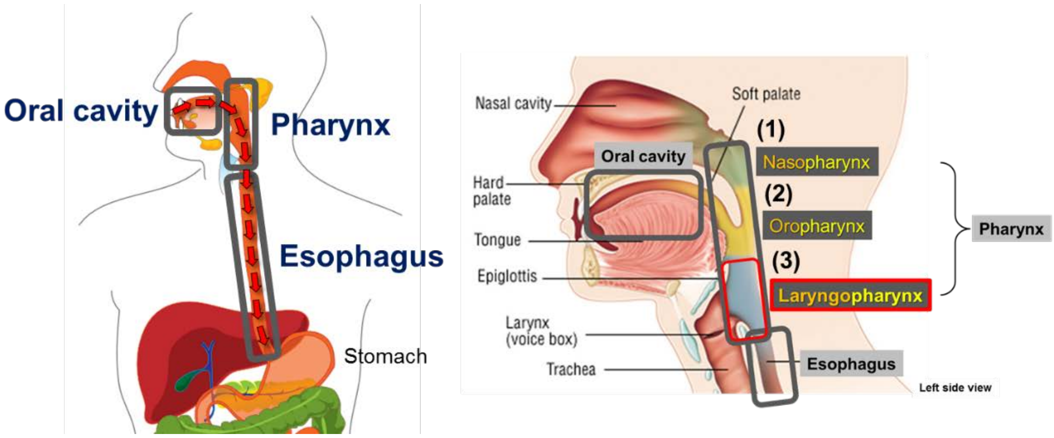
The remainder of the dissertation is organized into ten chapters. Chapter 1 describes the background, objectives, and significances of the study. Chapter 2 reviews literature relative to anatomy and physiology in swallowing, normal/abnormal swallow, and evaluation of dysphagia. Chapter 3 describes the swallowing screening algorithm based on the analysis of laryngopharynx-moved activities. Chapter 4 describes the swallowing quantification protocol applying the ultrasonic Doppler signal processing and the swallowing measure establishment. Chapter 5 describes the swallowing signal and measure interpretation result based on the analysis of VFSS images during swallowing. Chapter 6 describes the swallowing experiment for healthy people and patients with dysphagia to swallow various food types and volumes. Chapter 7 describes the analysis results such as the effects of age, gender, food type, and food volume on swallowing and the comparison of swallowing characteristics between healthy people and patients with dysphagia. Chapter 8 describes the diagnostic model for dysphagia using the swallowing measure to evaluate the severity of dysphagia. Chapter 9 discusses the significances, findings, limitations, and applications of the study. Lastly, Chapter 10 discusses the conclusion of the study.

Chapter 2 LITERATURE REVIEW

Literatures related to (1) anatomy and physiology in swallowing, (2) normal/abnormal swallow, (3) existing dysphagia evaluation methods, and (4) videofluorocopic swallowing study (VFSS) were reviewed in depth. First, structures and coordination principles of the pharynx-related organs involving in swallowing were comprehended. Second, causes and results of the normal/abnormal swallow phase were summarized. Third, symptoms and screening/diagnosis procedures of dysphagia were investigated with their limitations. Lastly, operation method and its limitations of VFSS, which has been widely used for dysphagia evaluation, were examined.

2.1. Anatomy and Physiology in Swallowing

The oral cavity, pharynx and esophagus constitute three anatomically and functionally integrated areas involved in swallowing as shown in Figure 2.1a. First, the oral cavity, which is bounded by the lips anteriorly, the cheeks laterally, and the tongue inferiorly, makes and tastes the bolus by suckling, chewing, and masticating food. Next, the pharynx, which is situated posterior to the nasal cavity, posterior to the mouth, and superior to the esophagus and larynx, is part of the digestive system and also of the conducting zone of the respiratory system. Lastly, the esophagus, which consists of a fibromuscular tube and is usually 18 ~ 25 cm long from the pharynx to the stomach, enables the bolus to pass by esophageal peristaltic contractions. The pharynx focused in the present study is



(a) Oral cavity, pharynx, esophagus (b) Classification of the pharynx

Figure 2.1. Anatomy in swallowing

anatomically classified into the (1) nasopharynx, (2) oropharynx, and (3) laryngopharynx as shown in Figure 2.1b. The ultrasonic Doppler sensor of the swallowing measurement system developed by Lee, Jung, et al. (2012) is attached on the laryngopharynx which is the lower part of the pharynx for measuring coordinating motions during swallowing.

The hyoid bone, epiglottis, thyroid cartilage, cricoid cartilage, and inferior pharyngeal constrictor at the laryngopharynx are involved in swallowing (Figure 2.2, Figure 2.3, and Figure 2.4). The hyoid bone, which is a horseshoe-shaped bone situated in the anterior midline of the neck between the chin and the thyroid cartilage, is articulated with the thyroid and cricoid cartilages by muscles, ligaments, and/or membranes as shown in Figure 2.2; therefore, if the hyoid bone is moved superiorly during swallowing, the thyroid and cricoid cartilages also are moved superiorly. In addition, the hyoid bone is

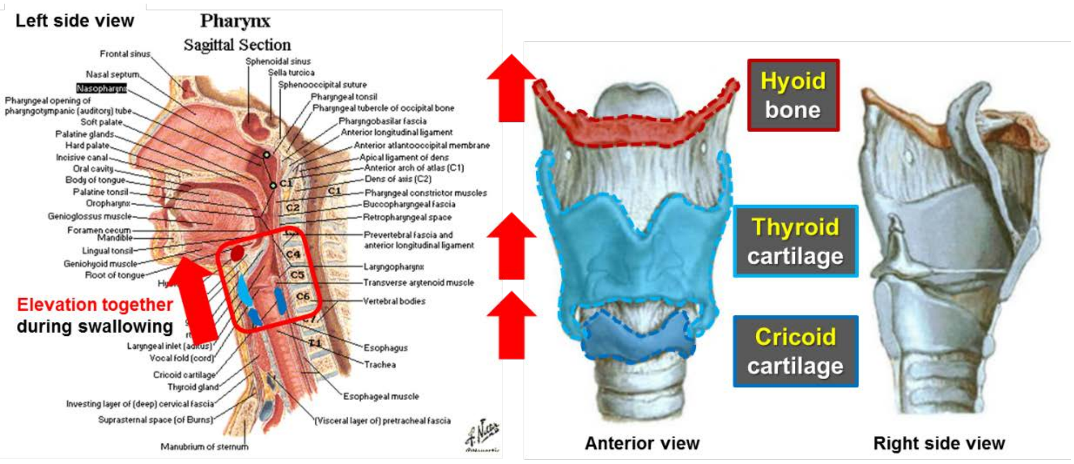


Figure 2.2. Anatomy of the hyoid bone, thyroid cartilage, and cricoid cartilage

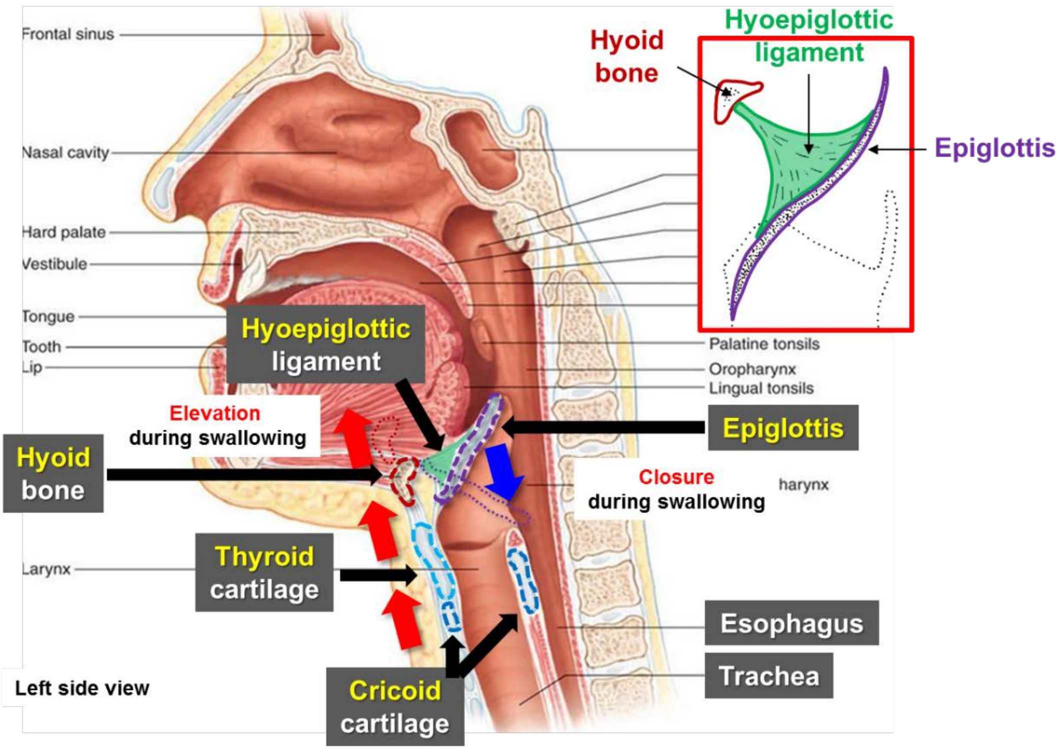


Figure 2.3. Anatomy of the hyoid bone and epiglottis

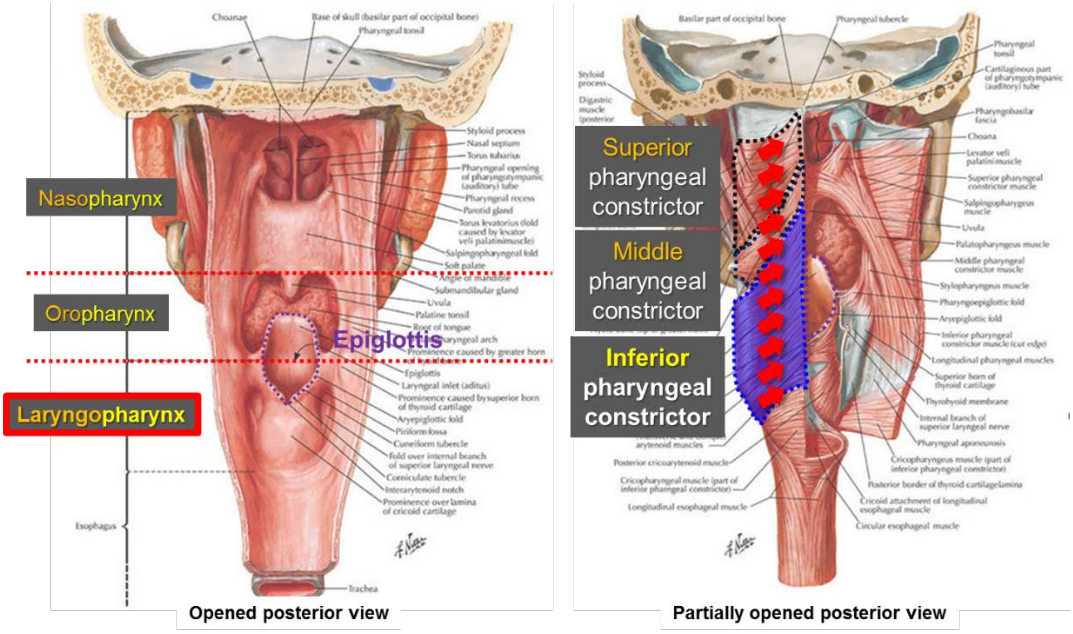


Figure 2.4. Anatomy of the pharyngeal constrictor

anchored with the epiglottis posterior by the hyoepiglottic ligament as shown in Figure 2.3; thus, if the hyoid bone is moved superiorly during swallowing, the epiglottis prevents the bolus from penetrating into the trachea and instead directs it to the esophagus due to its movement inferior. Lastly, the inferior pharyngeal constrictor, which is surrounding the pharynx as shown in Figure 2.4, passes the bolus inferior by contraction during swallowing.

2.2. Normal & Abnormal Swallow

2.2.1. Normal Swallow Stage

Normal swallow can be roughly categorized into the oral, pharyngeal, and esophagus stages as shown in Figure 2.5. Normal swallow is precisely scheduled, tuned, and coordinated in a precise and exact manner to establish a safe swallow (Dodds 1989; A. J. Miller, 1986). In the oral stage, the bolus is formed by moistening and masticating food using the tongue and teeth, corresponding to the oral preparatory stage, and is not allowed to leak anteriorly from the mouth through the lips. The oral preparatory stage can be dispensed for liquids depending on the willingness of the human. In the pharyngeal stage, the bolus is passed during approximately 1 s to the esophagus by anterior and superior movements of the hyoid bone and contraction of the pharyngeal constrictor, corresponding

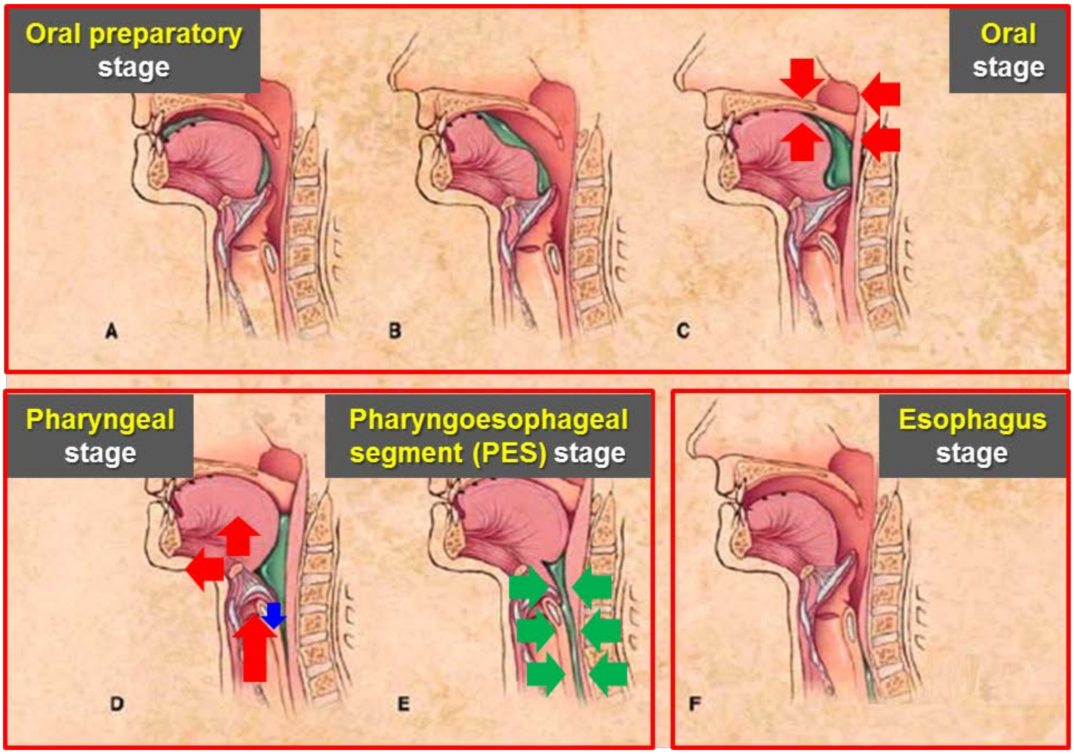


Figure 2.5. Normal swallow phases

to pharyngoesophageal segment stage (PES). In the esophagus stage, the bolus is passed during 6 ~ 10 s to the stomach by esophageal peristalsis.

In the pharyngeal stage out of the normal swallow phase, protection of the trachea (airway) from penetration of the bolus is occurred by pharyngeal shortening. The pharyngeal shortening, which shrinks the pharynx and closes opening of the trachea, could be the most important mechanism in pharyngeal bolus transport (Ergun, Kahrilas, Lin, Logemann, & Harig, 1993a; Ergun, Kahrilas, & Logemann, 1993b). As shown in Figure 2.6, the pharyngeal shortening protects the trachea by coordination among hyoid bone elevation, epiglottis folding, vocal folds closing, larynx elevation, and pharynx elevation (Curtis & Hudson, 1983; Curtis & Sepulveda, 1983; Ekberg, 1982). The elevation of the hyoid bone occurs voluntarily if the bolus is detected at the lower area of the oral cavity; therefore, the larynx and pharynx including the thyroid and cricoid cartilages articulated with the hyoid bone are elevated

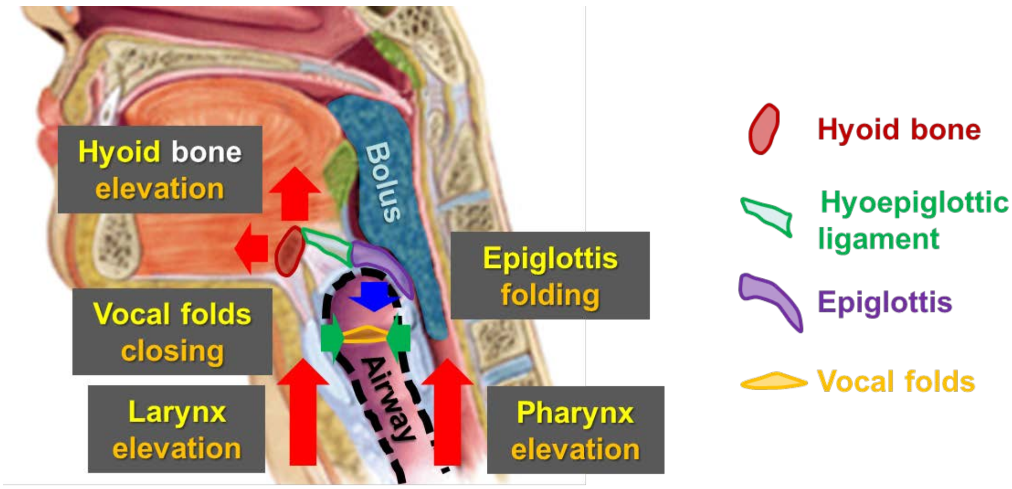


Figure 2.6. Pharyngeal shortening in the pharyngeal stage

simultaneously. In addition, when occurring the superior movement of the hyoid bone, the epiglottis articulated with the hyoepiglottic ligament is folded inferiorly to close the opening of the trachea and the vocal folds located near the opening of the trachea also is blocked for more rigid security. Accordingly, to breathe is impossible due to the closure of the vocal folds during the pharyngeal stage of swallowing. Thus, the pharyngeal shortening is the most important mechanism in swallowing to prevent from aspiration pneumonia mainly caused by the entrance the bolus (or foreign materials) into the lung not the esophagus (Ergun et al., 1993a; Ergun et al., 1993b).

2.2.2. Causes and Results of Abnormal Pharyngeal Swallow

Abnormal pharyngeal swallow can be caused by eight reasons such as reduced hyolaryngeal excursion and defective epiglottis inversions as presented in Figure 2.7. First, delayed swallowing reflex causes uncoordinated movements of swallowing-related organs due to occurring late initiation of the pharyngeal shortening which has to be conducted reflectively when the bolus passes through the oral cavity. Second, reduced velopharyngeal closure makes the bolus regurgate into the nasopharynx by occurring late closing of the velopharynx. Third, reduced hyolaryngeal excursion causes uncoordinated movements for the pharyngeal shortening due to occurring reduced anterior movements of the hyoid bone. Fourth, defective epiglottis inversion makes the bolus penetrate into the trachea due to unlocking the opening of the trachea by the epiglottis. Fifth, reduced laryngeal closure makes the bolus penetrate into the trachea due to occurring weak constriction of the

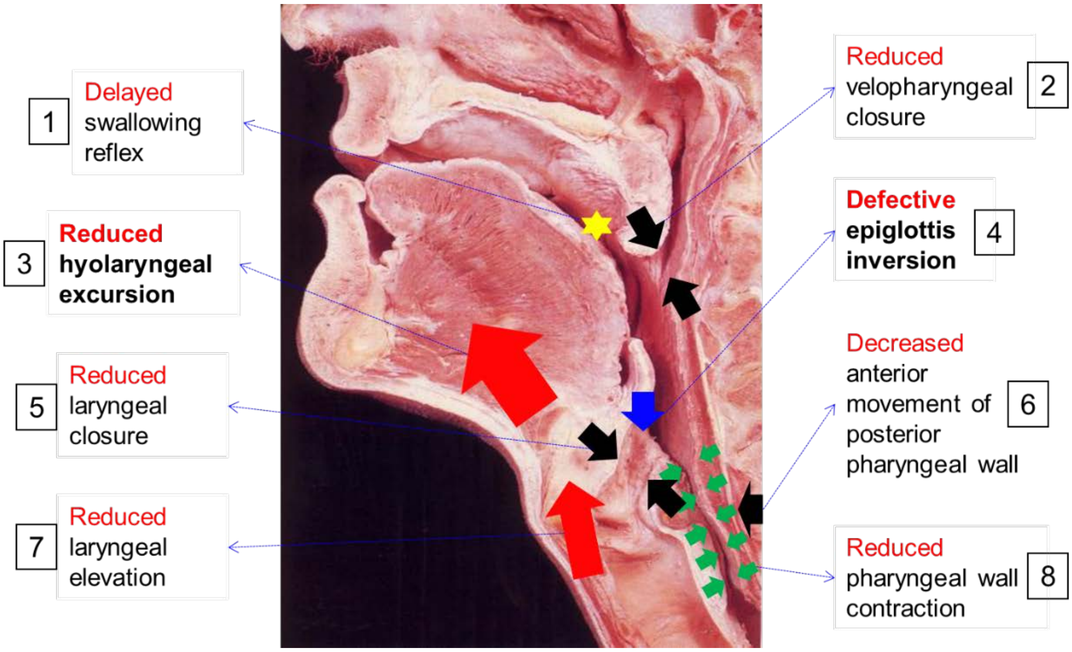


Figure 2.7. Causes of abnormal pharyngeal swallow

opening of the trachea. Sixth, decreased anterior movement of posterior pharyngeal wall makes the bolus transportation weaken due to occurring weak push force toward the larynx. Seventh, reduced laryngeal elevation causes uncoordinated movements for the pharyngeal shortening due to occurring weak anterior movements of the larynx. Lastly, reduced pharyngeal wall contraction makes pharyngeal peristalsis weaken. Meanwhile, the aforementioned causes of dysphagia can be occurred complexly.

Abnormal pharyngeal swallow can result in regurgitation, retention, and/or misdirected swallowing as shown in Figure 2.8. First, nasal regurgitation refers to that the bolus is passed into the nasopharynx not the laryngopharynx. Second, retention refers to that the bolus is halted in the vallecular and/or pyriform sinus not passed into the

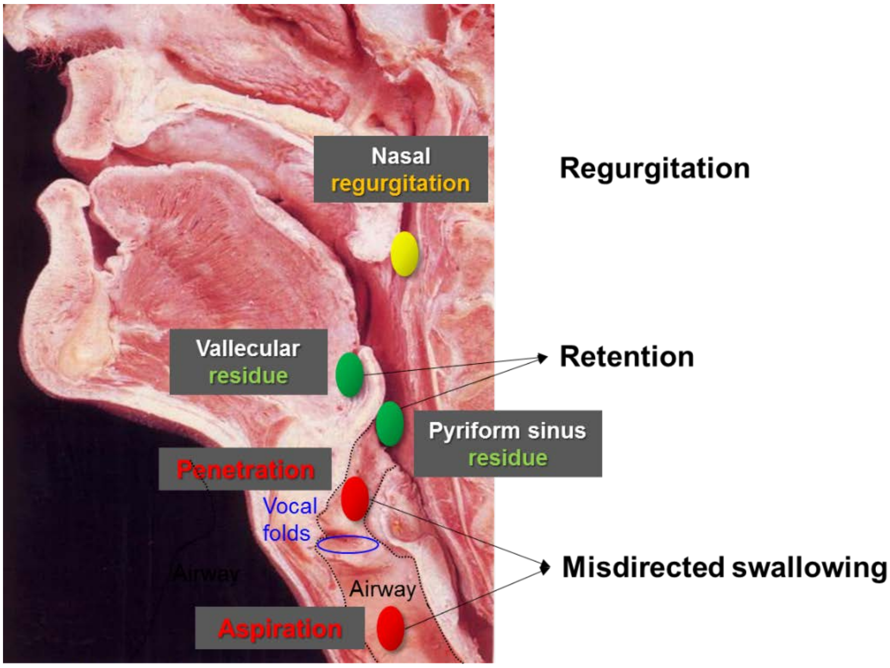


Figure 2.8. Results of abnormal pharyngeal swallow

esophagus. Lastly, misdirected swallowing causes penetration or aspiration by that the bolus is passed into the trachea not esophagus. Penetration means that the bolus reaches into the trachea during swallowing or merely only into the laryngeal vestibule and not beyond the vocal folds. Aspiration means that the bolus reaches into the trachea after swallowing and usually due to residue in the pharynx or beyond the vocal folds. Misdirected swallowing as a major cause of aspiration pneumonia induces accidental death due to asphyxia (Editorial, 1981; Lima, 1989). Estimated that number of deaths due to misdirected swallowing is 8,000 to 10,000; therefore, prevention of misdirected swallowing is important (Donner & Jones, 1985).

2.3. Evaluation of Dysphagia

2.3.1. Symptoms of Dysphagia

Symptoms of dysphagia are categorized into direct and indirect symptoms by Schröter-Morasch (1993) as shown in Figure 2.9. Direct symptom of dysphagia, which is observable with the naked eyes, includes prolonged duration of swallowing, pain, fear of swallowing, change of voice, avoidance of certain consistencies, drooling, obstruction, spitting, choking, coughing, and regurgitation. In contrast, indirect symptom of dysphagia, which needs specialized apparatus, includes aspiration, neurologic disease,

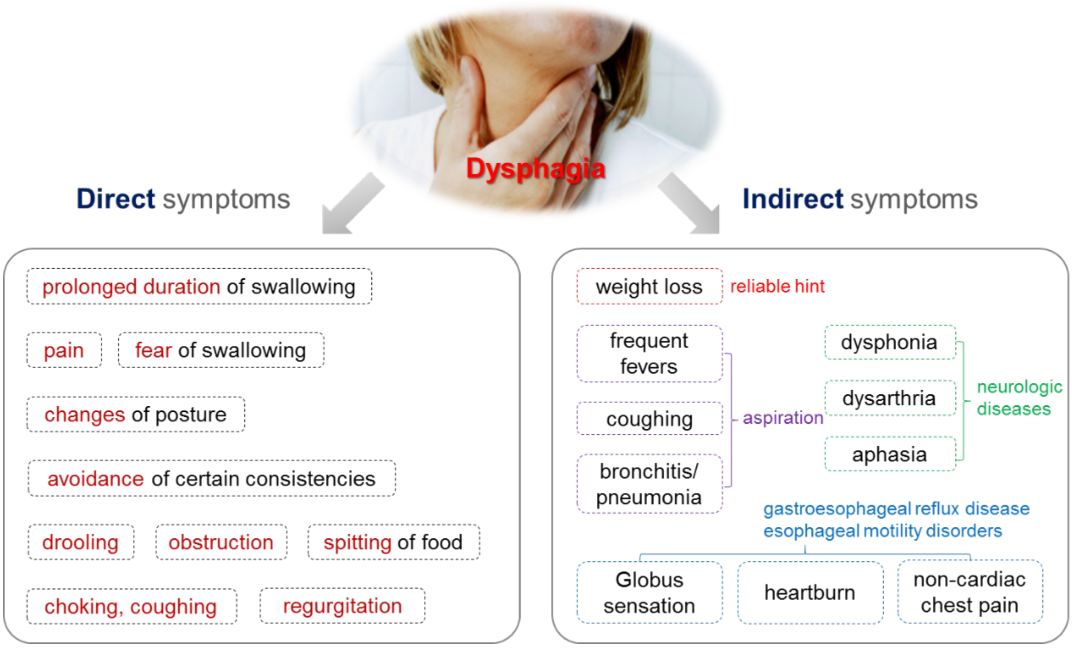
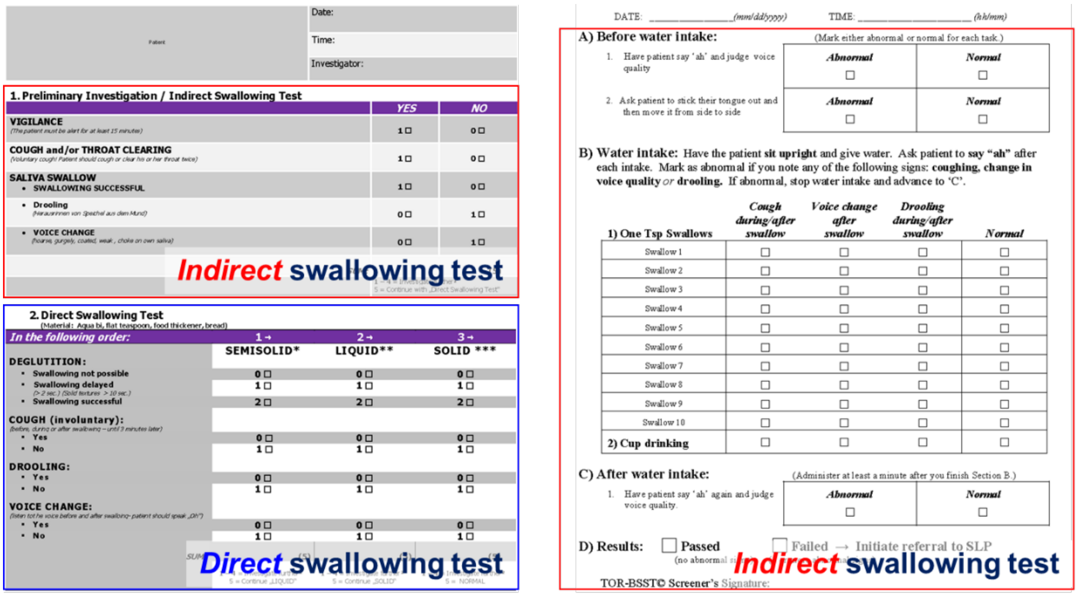


Figure 2.9. Symptoms of dysphagia (Schröter-Morasch, 1993)

gastroesophageal reflux disease, and esophageal motility disorder. Weight loss has been used as a reliable hint of dysphagia. Frequent fevers, coughing, and bronchitis/pneumonia have been used for screening aspiration; Dysphonia, dysarthria, and aphasia for neurologic disease; Globus sensation, heartburn, and non-cardiac chest pain for gastroesophageal reflux disease and esophageal motility disorder. Dysphagia has been screened and diagnosed referring to the aforementioned symptoms.

2.3.2. Screening Procedures of Dysphagia

For screening dysphagia, the combination of more than two tests has been recommended due to lacks of gold standard and common consent regarding who should perform the screening and how it should be carried out. No gold standard for screening dysphagia exists, and the various studies often cannot be compared due to different protocols, missing validation, and small samplings. For example, the Gugging Swallowing Screen (Figure 2.10a) uses semisolid, liquid, and slid textures in direct swallowing test and observes a saliva swallow in indirect swallowing test (Trapl et al., 2007). The Toronto Bedside Swallowing Screening Test (Figure 2.10b) considers indirect aspects, such as mobility of the tongue and voice quality, before and after the water swallows (Martino et al., 2009). In addition, needed that common consent regarding who and how out of five W’s and one H for screening dysphagia. For example, water or thicker consistency swallows can be conducted by health care team or speech language pathologist. Lastly, to increase the sensitivity and specificity, the combination of multiple tests has been suggested, but the discussion remains controversial. For example, Lim et al. (2001) revealed that a water test in combination with pulse oximetry (Figure 2.11) is appropriate to detect aspiration; whereas, Leder (2000) stated that not suitable.



(a) Gugging Swallowing Screen (Trapl et al., 2007)

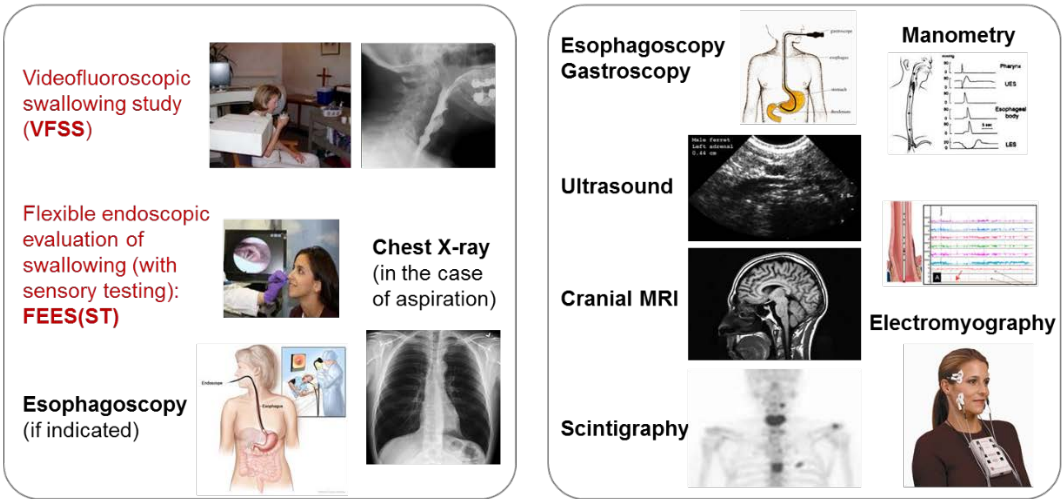
(b) Toronto Bedside Swallowing Screening Test (Martino et al., 2009)

Figure 2.10. Representative screening tests for dysphagia

Figure 2.11. Water test in combination with pulse oximetry

2.3.3. Diagnostic Procedures of Dysphagia

Dysphagia has been diagnosed by applying compulsory and in-depth diagnostic procedures as shown in Figure 2.12. Compulsory diagnostic methods (Figure 2.12a) aim at revealing the components of dysphagia, especially proving or excluding aspiration and have been obligatorily used in clinics. For example, videofluoroscopic swallowing study (VFSS), non-invasive dynamic procedure, delivers an immediate evaluation of pharyngeal swallowing function and directly visualizes the upper aerodigestive tract using a special movie-type X-ray (called fluoroscopy) during swallowing (Langmore et al., 1988). In-depth diagnostic methods (Figure 2.12b) aim at recommendations for therapy and type of feeding, as well as indications for emergency therapies such as tracheostomy in the case of



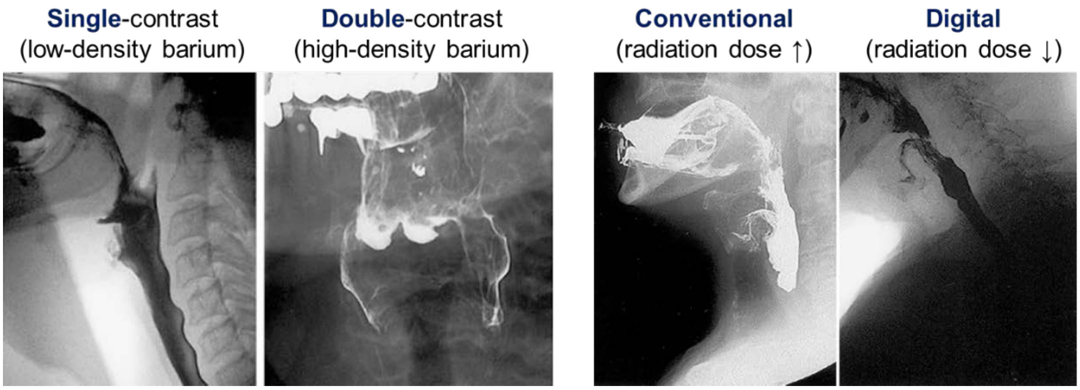
(a) Basic diagnostic method (compulsory) (b) Further diagnostic method (optional)

Figure 2.12. Diagnostic procedure of dysphagia

intractable aspiration. For example, manometry has been used to evaluate physiologic mechanisms for therapeutic planning by calculating quantitative information on swallowing physiology such as timing and pressure associated with the swallow (Butler, 2009; Butler et al., 2009; Hiss & Huckabee, 2005; Huckabee, Butler, Barclay, & Jit, 2005).

2.4. Videofluoroscopic Swallowing Study (VFSS) and its Limitations

VFSS has been used especially to assess misdirected swallowing, but is necessary being used with care because may cause cell death or induce serious late side effects. VFSS focuses on bolus transportation as well as registration of morphodynamic events. In VFSS, barium, iodine, or solid bolus transportations are examined at least 15 swallows in such patients in common (Westen & Ekberg, 1993). VFSS using barium has been widely performed to examine both function and morphology by using low-density barium (single-contrast) and high-density barium (double-contrast) as shown in Figure 2.13a. Meanwhile, ionized radiation absorbed 80 ~ 99% (≈ 1 mSv/shot) to the patient in VFSS may interfere with water molecules, proteins, and other important substances within the cell and cause free radicals to be produced as shown in Figure 2.14 (Chan, Chan, & Lam, 2002). Accordingly, modern VFSS has been tried to reduce radiation doses by adopting digital radiology (Figure 2.13b); but, still may induce side effects to the human body (Ekberg, 2012). Therefore, VFSS, which can be effectively used to diagnose dysphagia, needs to be properly performed by dysphagia expert.



(a) By density of barium (b) By radiation dose

Figure 2.13. Classifications of VFSS image

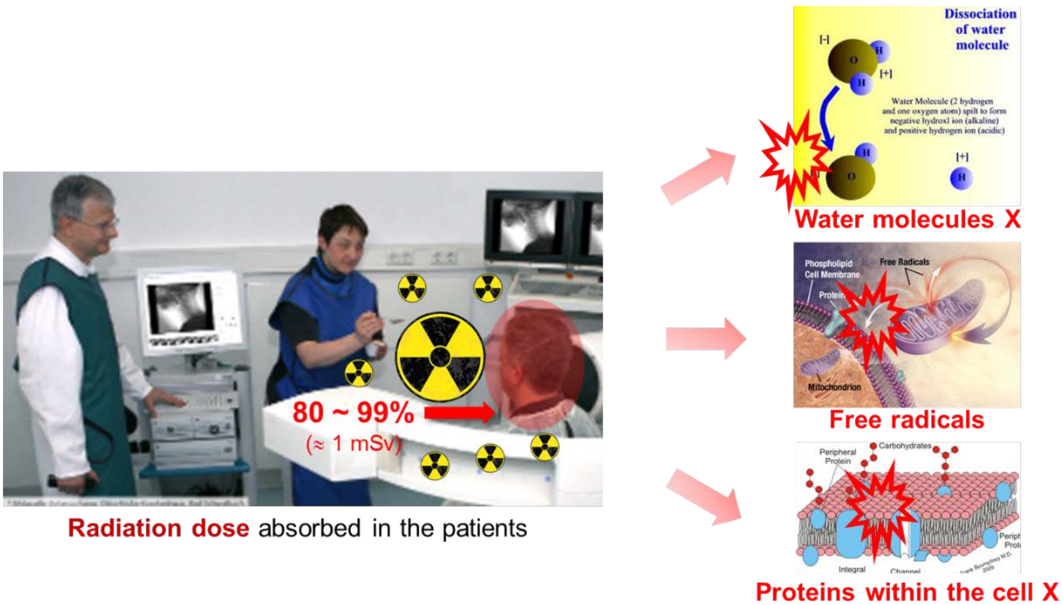


Figure 2.14. Negative effects of VFSS

2.5. Swallowing Measurement Device (SMD) Using Ultrasonic Doppler

The precedent study (Lee, Jung, et al., 2012) of the present study developed a novel device for measuring swallowing movements as shown in Figure 2.15. The swallowing measurement device (SMD, Xtron I&T Co., South Korea) converts the swallowing movement into a swallowing signal. The SMD consists of an ultrasonic Doppler sensor for measuring movements of the pharynx, a main body for converting the swallowing movement measured into the swallowing signal, and a USB port for transmitting the swallowing signal into a PC. As shown in Figure 2.16a, the ultrasonic Doppler sensor (frequency = 2 MHz, element length × width = 5 × 6 mm, pitch = 6 mm, transducer surface radius = 158R; DEPST-D2M5C, Digital Echo Co., South Korea) is composed of one transmitter and two receivers and its surface is designed with a curved line for ease attachment on the neck. As shown in Figure 2.16b, the ultrasonic Doppler sensor can be

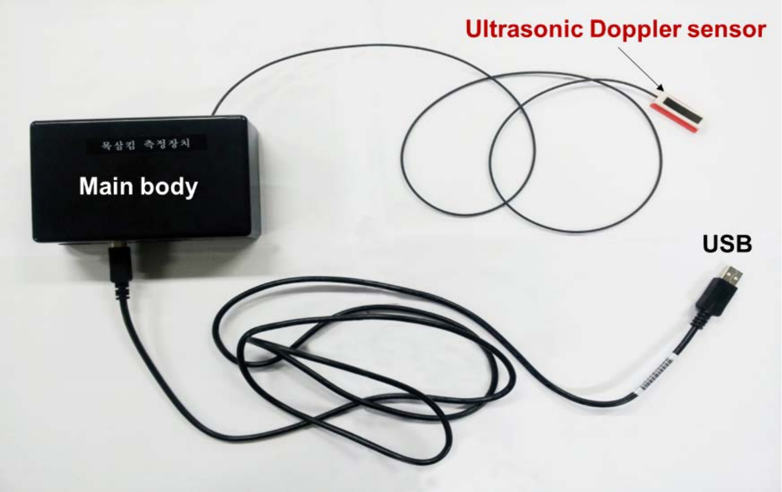
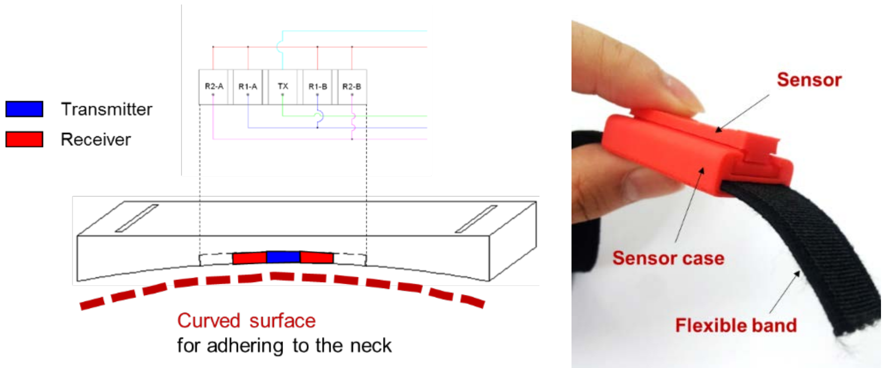


Figure 2.15. Swallowing measurement device (SMD)

attached to a designated part on the neck by using a sensor case and flexible band. As shown in Figure 2.17, the analysis S/W of the SMD has a function for synchronization between swallowing signal and VFSS video with a real-time plotting.



(a) Transmitter and receiver (b) Sensor case and flexible band

Figure 2.16. Ultrasonic Doppler sensor of the SMD

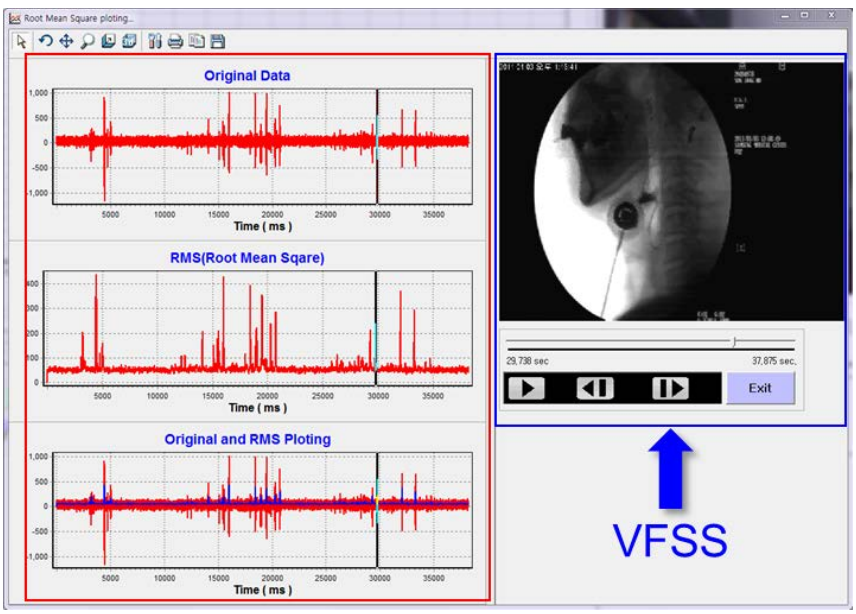


Figure 2.17. Analysis S/W of the SMD

Chapter 3 SWALLOWING SCREENING

A swallowing screening algorithm was developed to screen only swallowing activities out of laryngopharyngeal movements (e.g., swallowing, cough, vocalization, respiratory, and neck movement) measured by the ultrasonic Doppler sensor of the SMD. A miniature microphone was additionally employed into the SMD for measuring audios occurred in laryngopharyngeal movements. The swallowing screening algorithm applied a concept of swallowing apnea using both laryngopharyngeal movement and audio signals and its effectiveness was evaluated to healthy adults.

3.1. Analysis of Unique Characteristics during the Pharyngeal Swallow

A major characteristic of swallowing for discriminating with cough and vocalization is that vocalizations cannot be generated from the vocal fold at least 1 sec during the pharyngeal swallow. Figure 3.1 shows laryngopharyngeal movement signals of swallowing, cough, and vocalization measured by the ultrasonic Doppler sensor of the SMD. Found that the discrimination of swallowing with cough and vocalization through measurement of the laryngopharyngeal movement was difficult because laryngopharyngeal movement signals of cough and vocalization have similar with those of swallowing. Based on literature review, the present study found that the swallowing apnea is a brief period in which breathing ceases just before and during all the pharyngeal phase of swallowing and makes

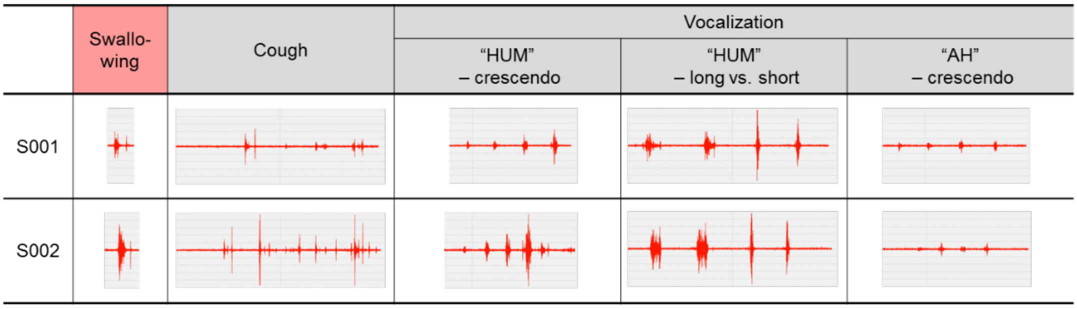


Figure 3.1. Ultrasonic Doppler signals of measurements during swallowing, cough, and vocalization

vocalization impossible due to the laryngopharyngeal protective mechanism (pharyngeal shortening; Figure 2.6) for preventing an invasion of the bolus into the airway (trachea) including the laryngeal closure and the vocal fold closure (Loch, Loch, Reiriz, & Loch, 1982; Nishino, 1990; Ren et al., 1993). The range of the swallowing apnea duration of healthy adults was 1 ~ 3 sec regardless of age, gender, food type, and food volume and the minimum was 1 sec (Radish & Jayashree, 2012). Therefore, at least 1 sec-vocalization during the pharyngeal swallow, at least before-and-after 0.5 sec-vocalization from a laryngopharyngeal movement peak, is impossible due to the swallowing apnea. In other words, at least before-and-after 0.5 sec-swallowing is impossible from an audio peak as shown in Figure 3.2.

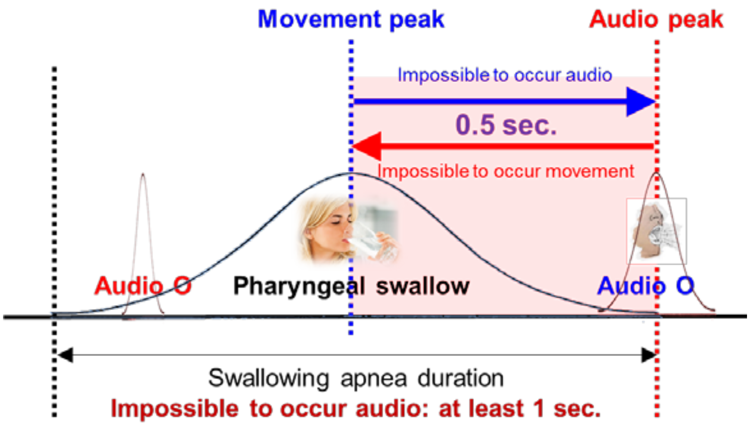


Figure 3.2. Swallowing apnea duration on pharyngeal movement and audio signals

3.2. Synchronization of the SMD with Microphone

A miniature microphone was employed into the SMD for acquisition of audio signals during the laryngopharyngeal movement. The ultrasonic Doppler sensor (frequency = 2 MHz, amplitude = 94 mW/cm^2, power = 20 mW; SeedTech, Co., South Korea) and the microphone (sensitivity = -38 ~ 48 dB, frequency = 50 ~ 16 kHz, S/N ratio > 60 dB; PBM Electech, Co., South Korea) were attached at the case of the SMD to measure simultaneously a laryngopharyngeal movement and audio signals as shown in Figure 3.3.

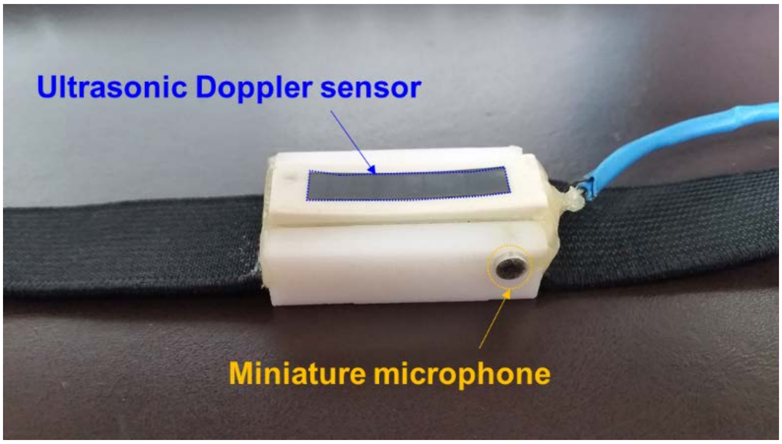
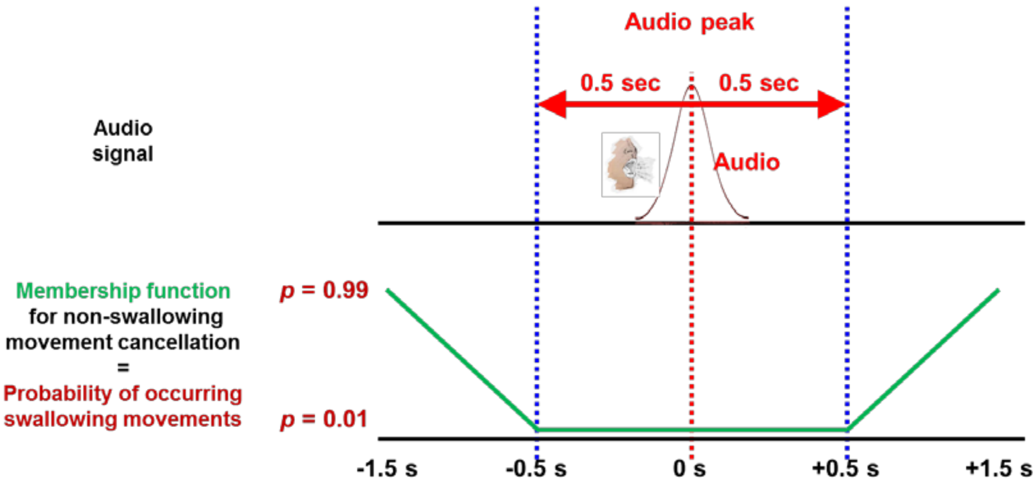


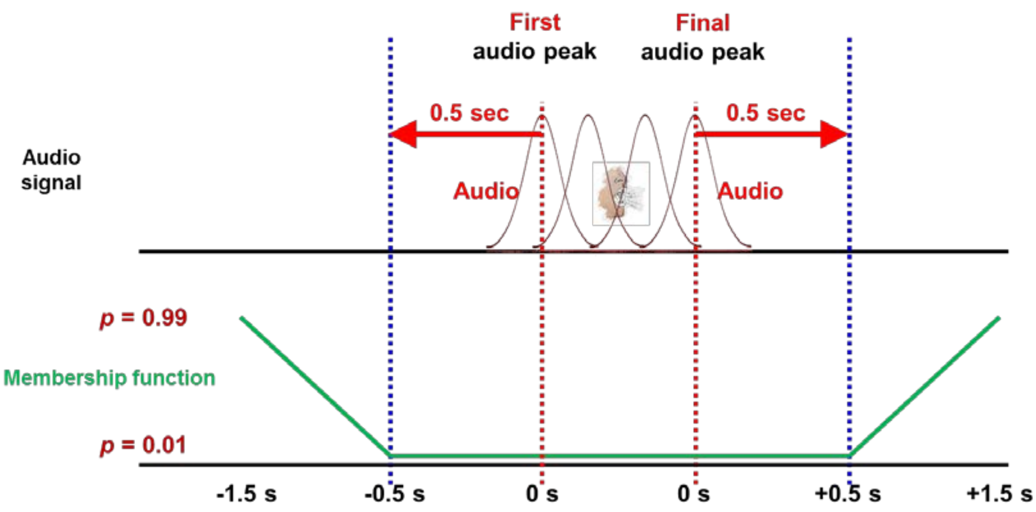
Figure 3.3. Interoperation of ultrasonic Doppler sensor with miniature microphone

3.3. Development of a Swallowing Screening Algorithm

A set of membership functions of which the probability distribution of occurring swallowing movements according to the laryngopharyngeal movement time was developed for cancellation of laryngopharyngeal movements occurred during cough and vocalization. As presented in Figure 3.4a, the membership function for uni-audio peak was set up with 1% within ± 0.5 sec from an audio peak, linearly increasing probabilities from ± 0.5 sec to 1.5 sec, and 99% beyond ± 1.5 sec, considering the maximum swallowing apnea duration (total 3 sec). As presented in Figure 3.4b, the membership function for multi-audio peak was set up with 1% within - 0.5 sec from the first audio peak and + 0.5 sec from the last audio peak, because the swallowing process cannot be occurred during vocalization due to an anatomical and functional coordination of the vocal fold.



(a) Membership function for uni-audio peak



(b) Membership function for multi-audio peak

Figure 3.4. Membership functions for non-swallowing movement cancellation

A 5-step swallowing screening algorithm (S1. smoothing, S2. audio peak detection, S3, membership function application, S4, audio binary conversion, S5. swallowing peak detection) was developed as shown in Figure 3.5. First, in the smoothing step, noises of the audio signal are eliminated and peaks are clarified by applying the moving average technique with lag n = 50 (Lee, Jung, et al., 2012) in terms of both laryngopharyngeal movement and audio signals. Second, in the audio peak detection step, audio peaks with above the cutoff value 0.15 mV are regarded as target audio peaks out of all audio peaks. Third, in the membership function application step, laryngopharyngeal movement signal is multiplied by the MLF for uni-or multi-audio peak. Fourth, in the audio binary conversion step, audio signal is converted into 1 of which audio signal value > cutoff value and 0.01 of which otherwise for stabilization including noise cancellation. Lastly, in the swallowing peak detection step, movement-to-audio ratio (= movement signal value / audio signal value) is calculated and then peaks of movement-to-audio signal with more than a designated cutoff value are regarded as swallowing. Meanwhile, the swallowing screening algorithm was implemented using Matlab 2011a for automatic calculation of movement-to-audio ratio given laryngopharyngeal movement and audio signals measured and relative parameter values such as cutoff values for audio peak.

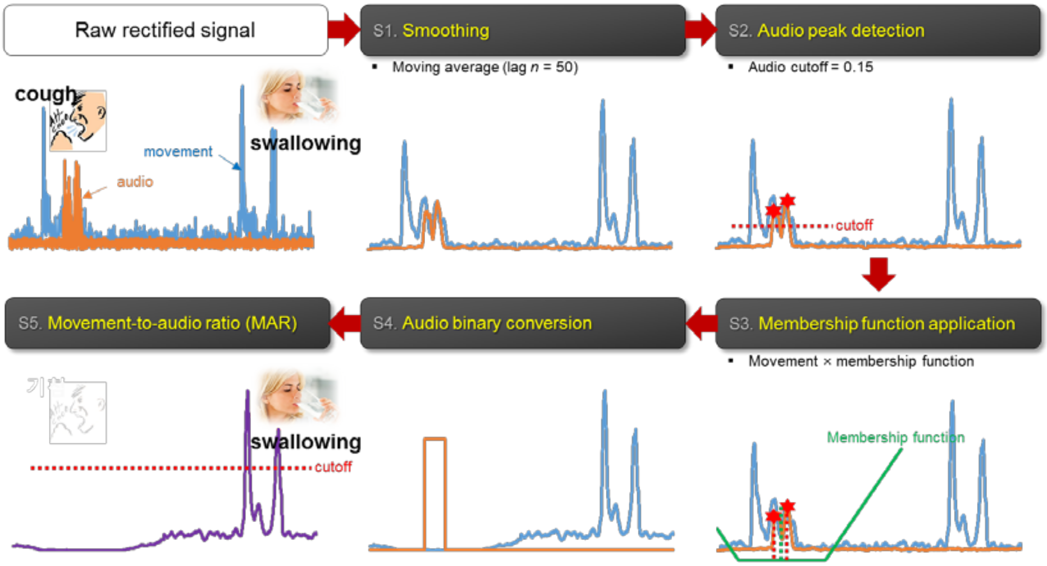


Figure 3.5. Swallowing screening algorithm (blue line: movement signal, orange line: audio signal, green line: membership function, purple line: movement-to-audio ratio)

3.4. Validation of the Swallowing Screening Algorithm

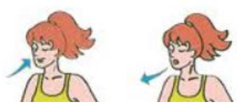
Laryngopharyngeal movement and audio signals during swallowing, vocalization, cough, respiratory, and neck movement were measured three times to five healthy males in 20s for validation of the swallowing screening algorithm. The experiment was conducted for each experimental condition as follows: (1) swallowing by drinking water 1 ml, (2) vocalization by reading random one sentence with less than 50 words, (3) cough for intentional cough, (4) respiratory for nose, mouse, and both together, and (5) neck movement for left/right, up/down, and rotation. The 5 × 5 balanced Latin square as presented in Table 3.1 was applied to the experiment.

Table 3.1. Experimental order by 5 × 5 balanced Latin square

Subject	1st trial	2nd trial	3rd trial	4th trial	5th trial
S01	swallowing	vocalization	cough	respiratory	neck movement
S02	vocalization	cough	neck movement	swallowing	respiratory
S03	cough	neck movement	respiratory	vocalization	swallowing
S04	respiratory	swallowing	vocalization	neck movement	cough
S05	neck movement	respiratory	swallowing	cough	vocalization

The swallowing was discriminated 100% with the cough, vocalization, and respiratory and 73% with the neck movement (Table 3.2). As shown in Figure 3.6, the swallowing screening algorithm can accurately screen only swallowing movements out of various laryngopharyngeal movements. The cough and vocalization occurring both the laryngopharyngeal movement and audio and the respiratory rarely occurring the laryngopharyngeal movement were discriminated 100% from the swallowing. The neck movement leftward, rightward, upward, and downward was discriminated 100% from the swallowing due to lack of laryngopharyngeal movements, but the neck rotation was not discriminated 27% (4/15 trials) due to partial occurrence of laryngopharyngeal movements.

Table 3.2. Swallowing screening results (O: peak amplitude < cutoff, X: o/w)

									
		cough	**vocalization**	**respiratory**			**neck movement**		
				nose	mouse	both	left/right	up/down	rotation
Movement		O	O	X	X	X	X	X	O
Audio		O	O	X	X	X	X	X	X
S01 (cutoff = 80)	1^{st}	O	O	O	O	O	O	O	O
	2^{nd}	O	O	O	O	O	O	O	O
	3^{rd}	O	O	O	O	O	O	O	O
S02 (cutoff = 80)	1^{st}	O	O	O	O	O	O	O	O
	2^{nd}	O	O	O	O	O	O	O	O
	3^{rd}	O	O	O	O	O	O	O	O
S03 (cutoff = 40)	1^{st}	O	O	O	O	O	O	O	O
	2^{nd}	O	O	O	O	O	O	O	O
	3^{rd}	O	O	O	O	O	O	O	X
S04 (cutoff = 40)	1^{st}	O	O	O	O	O	O	O	X
	2^{nd}	O	O	O	O	O	O	O	O
	3^{rd}	O	O	O	O	O	O	O	O
S05 (cutoff = 80)	1^{st}	O	O	O	O	O	O	O	X
	2^{nd}	O	O	O	O	O	O	O	X
	3^{rd}	O	O	O	O	O	O	O	O
Discriminant rate (%)		**100%**	**100%**	100%	100%	100%	100%	100%	73%
					100%			**91%**	

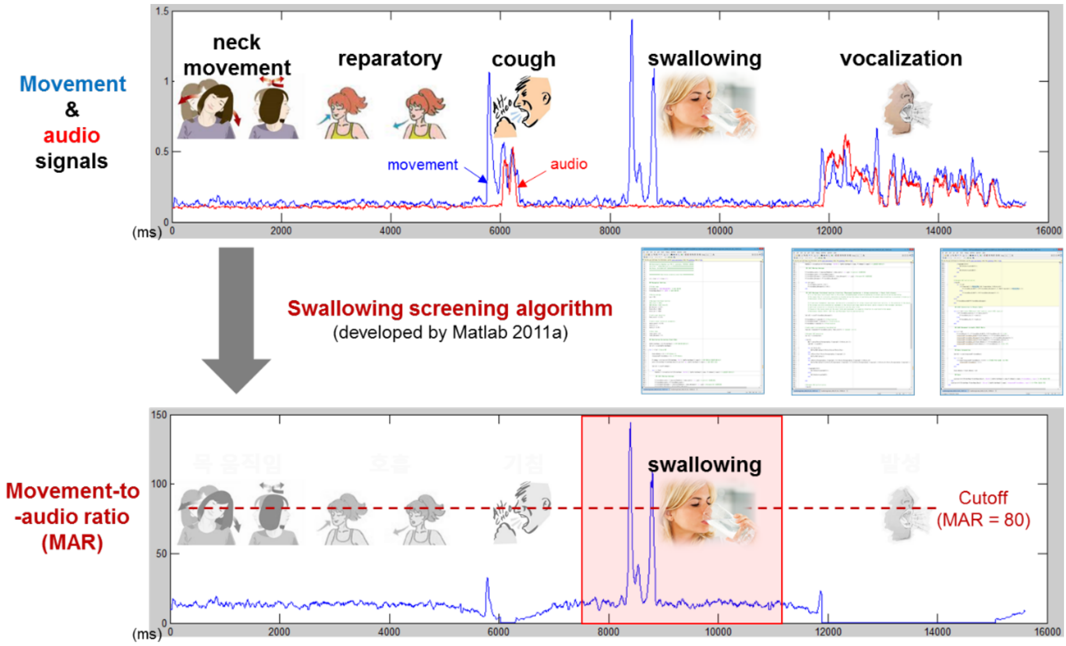
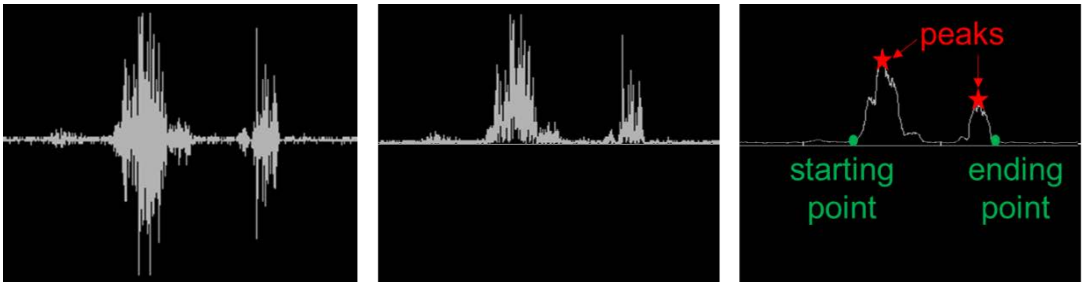


Figure 3.6. Example of non-swallowing movement cancellation

Chapter 4 SWALLOWING QUANTIFICATION

4.1. Quantification of a Swallowing Signal

A swallowing signal measured by ultrasonic Doppler was quantified by applying as following four steps as shown in Figure 4.1: (1) signal rectification, (2) signal smoothing, (3) peak detection, and (4) starting/ending point detection. First, in the signal rectification step, negative amplitude values (unit: mV) of raw signal were converted into positive amplitude values of that as shown in Figure 4.1a. Second, in the signal smoothing step, the moving average technique was applied to the rectified signal (Figure 4.1b) for reducing noise and clarifying peaks. Third, in the peak detection step, peaks which refer to local maxima on the smoothed signal were detected when showing a higher amplitude value compared to the designated cut-off value (e.g., 5 mV) (Figure 4.1c). Lastly, in the starting/ending points detection step, initiation and termination timings which refer to local minima from the selected peaks were detected (Figure 4.1c). The present study used lag n = 50 ms and cut-off value = 5 mV recommended by the precedent study (Lee, Lee, et al., 2012) which has developed the SMD and analyzed swallowing signals of each 10 healthy people and 10 patients with dysphagia. In addition, the present study extracted one peak within one convex signal through upward adjustment of cut-off value up to 20 mV.



(a) Raw signal (b) Rectified signal (c) Smoothed signal

Figure 4.1. Quantification procedure of swallowing signal
(*x* axis: time; *y* axis: amplitude)

4.2. Establishment of Swallowing Quantification Measures

For quantification of swallowing characteristics, five swallowing quantification measures were established as shown in Figure 4.2: peak amplitude, duration time, number of peaks, peak-to-peak interval, and impulse. First, peak amplitude (unit: mV) refers to height of peak extracted from the smoothed signal. For example, Figure 4.3 shows a swallowing signal indicating highest peak amplitude = 112.8 mV and 2^{nd} highest peak amplitude = 51.3 mV. Second, duration time (unit: ms) refers to time difference between starting point and ending point. For example, in Figure 4.3, duration time = 1,002 ms calculated by 3,383 ms (ending point) – 2,381 ms (starting point). Third, number of peaks refers to total number of peaks extracted from the peak detection step. For example, in Figure 4.3, number of peaks = 2 satisfying their cut-off values ≥ 5 mV. Forth, peak-to-peak interval (unit: ms) refers to time difference between peaks when number of peaks ≥ 2. For example, in Figure 4.3, peak-to-peak interval = 671 ms calculated by 3,374 ms (2^{nd} highest

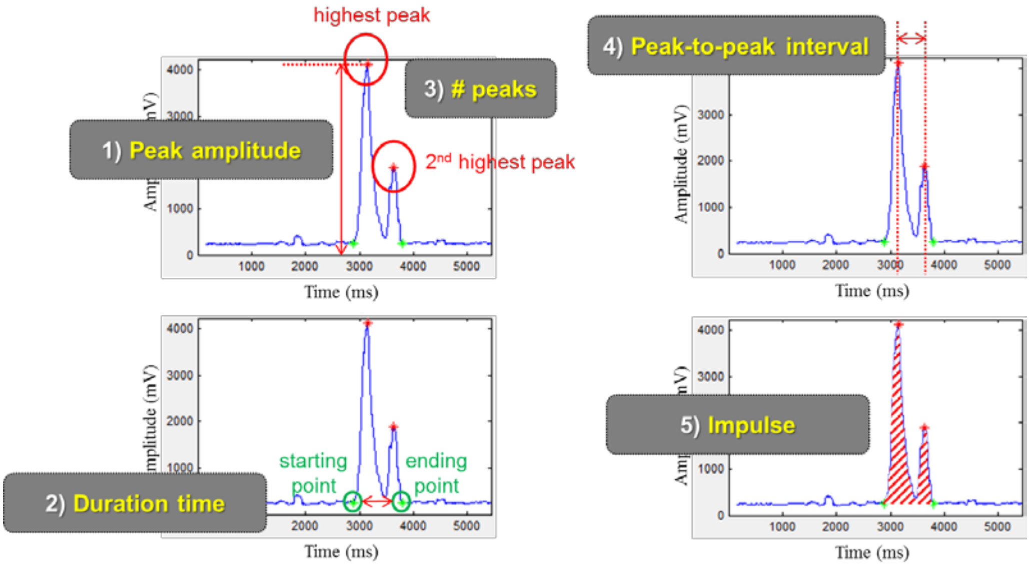


Figure 4.2. Swallowing quantification measures

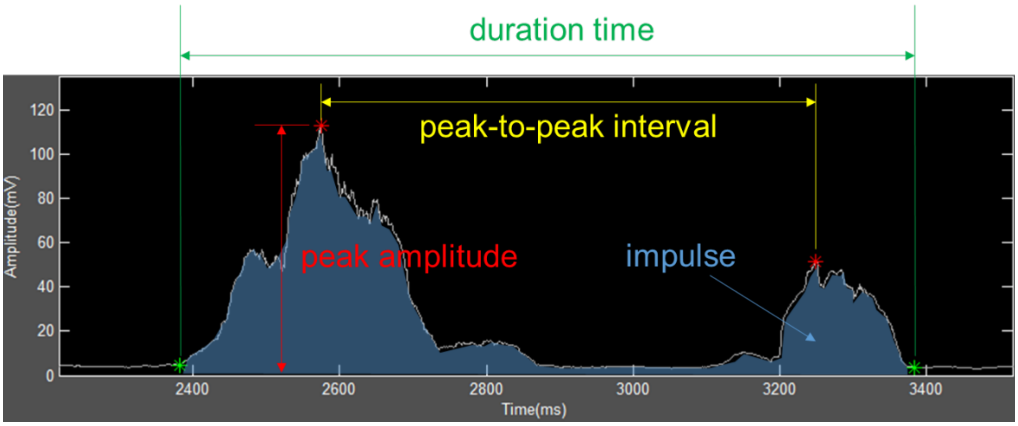


Figure 4.3. Example of swallowing signal of healthy adult

peak) – 2,703 ms (highest peak). Lastly, impulse (unit: msec × mV) refers to area from starting point to ending point of the swallowing signal and is calculated by Equation 3.1. For example, in Figure 4.3, impulse = 28,812 msec × mV calculated by Equation 3.1 satisfying starting point = 2,381 ms and ending point = 3,383 ms.

$$Impulse = \sum_{i=SP}^{EP} a_i$$ Equation 4.1

where, $\boldsymbol{a_i}$ = amplitude (mV) at time *i* (msec)

SP = starting point

EP = ending point

4.3. Development of a Swallowing Quantification Program

A swallowing quantification program (SQP), as shown in Figure 4.4, which automatically calculates the swallowing quantification measures was developed in the present study. The SQP computes values of the swallowing quantification measure such as peak amplitude, duration time, number of peaks, peak-to-peak interval, and impulse and those descriptive statistics such as mean, *SD*, min, and max by loading a measured swallowing signal and then setting a lag *n* for moving average and a cut-off value for peak detection. In addition, two interactive functions conducted by mouse click directly were implemented to adjust range of the swallowing signal for analysis and starting/ending points extracted by the corresponding algorithm. For example, as shown in the raw signal of Figure 4.4, user-defined range of the swallowing signal can be generated by designating initiation and termination points directly as emerald dotted lines. As shown in the smoothed signal of Figure 4.4, algorithm-based starting point (5,042 ms) can be revised into user-defined starting point (5,098 ms) considering proper swallowing analysis.

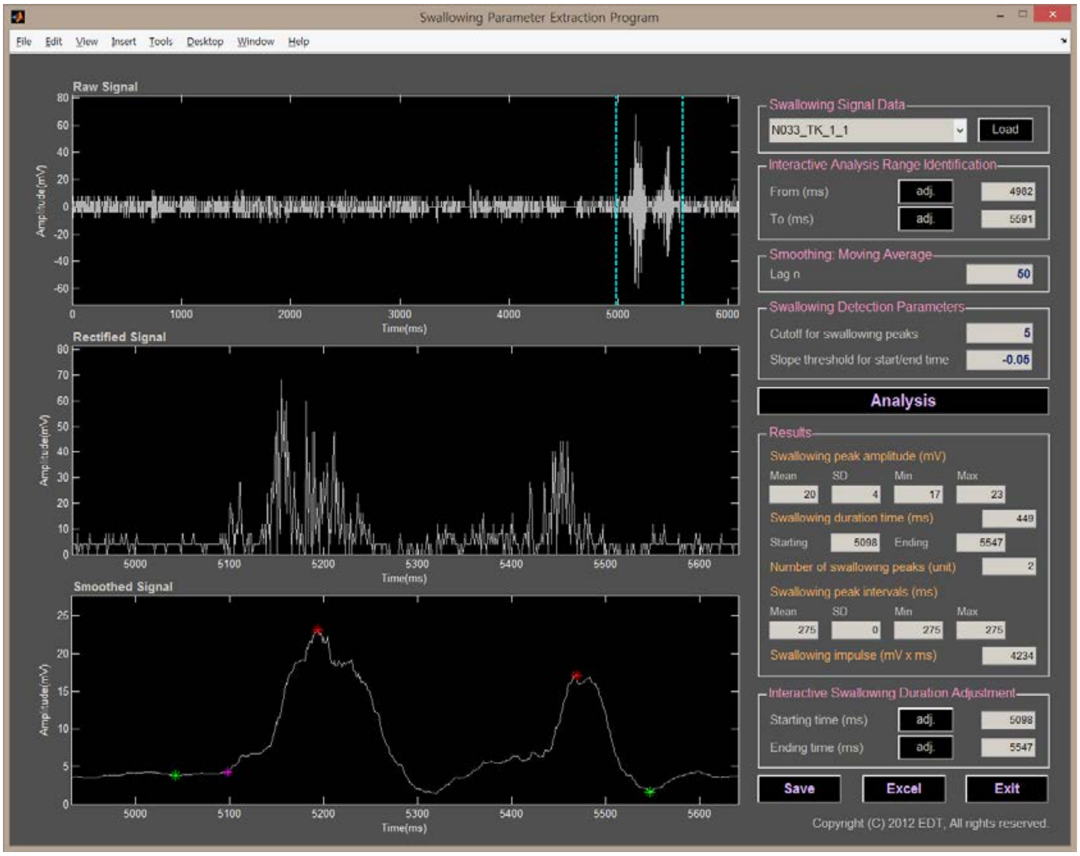


Figure 4.4. Swallowing quantification program

Chapter 5 SWALLOWING INTERPRETATION

5.1. Synchronization of Swallowing Signal and VFSS Video

VFSS videos synchronized with the swallowing signal during swallowing were acquired for interpretation of the swallowing signal. Nine VFSS videos and signals during swallowing water 1 ml were measured to healthy female aged 20s with normal swallowing capability using the SMD (Figure 2.15) and fluoroscopy system (Sonialvision G4, Shimadzu Co., Japan; Figure 5.1). The analysis S/W of the SMD (Figure 2.17), developed in Lee, Jung, et al. (2012), was used for synchronized measuring and plotting swallowing signal and VFSS video during swallowing. As a result of measurements, found that eight swallowing signals had two peaks and one swallowing signal had three peaks, as shown in

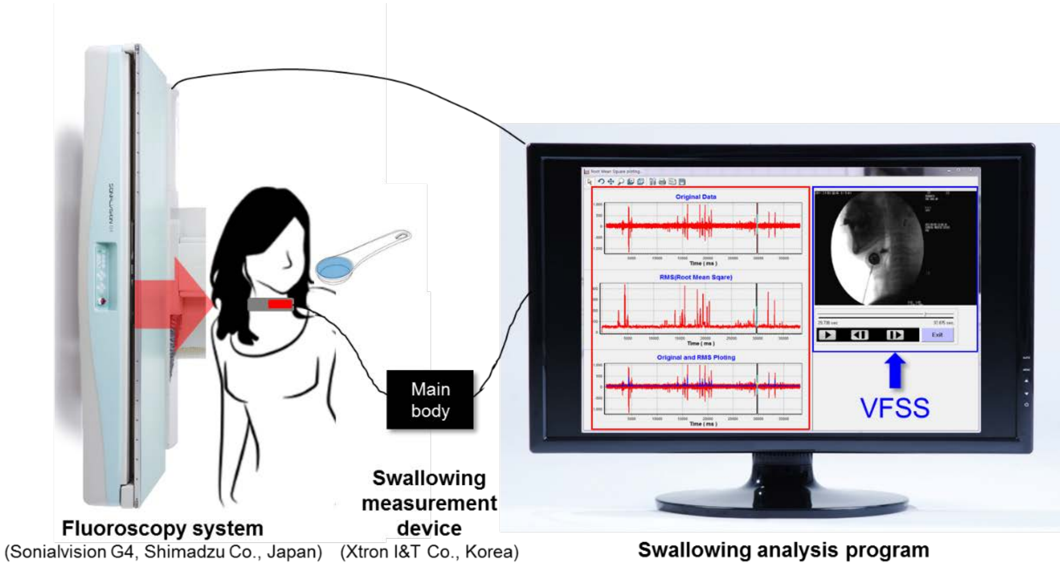


Figure 5.1. Acquisition of swallowing signal with VFSS video

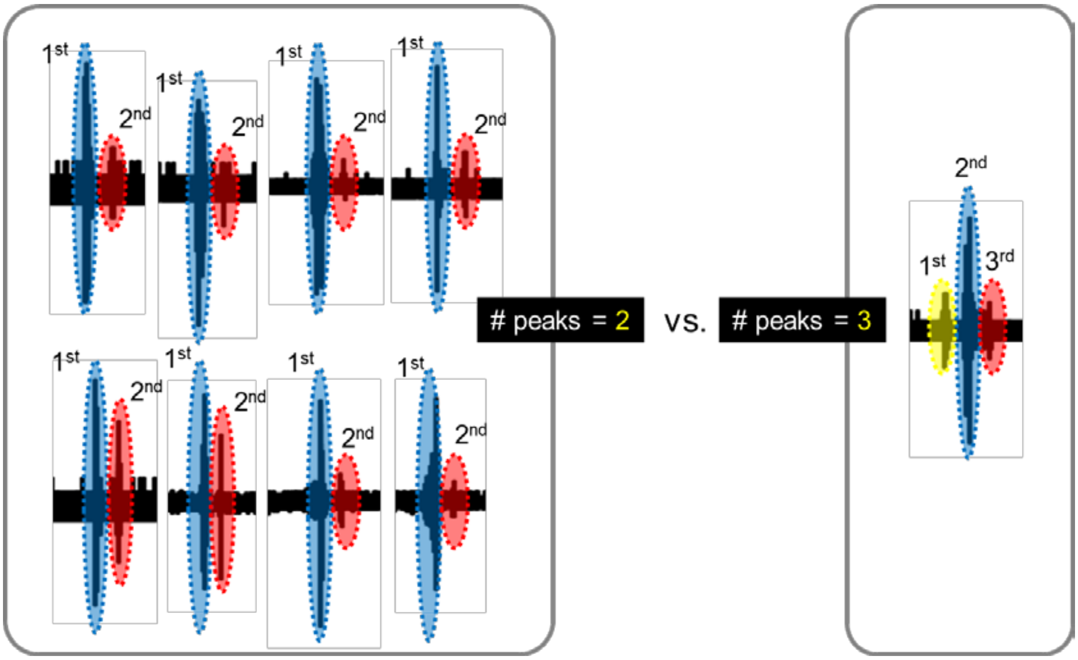


Figure 5.2. Different number of peaks in one healthy adult

Figure 5.2, out of the measured nine swallowing signals; thus, the present study interpreted both swallowing case showing two peaks and that showing three peaks.

5.2. Interpretation of Swallowing Signals

Method

Movements of the laryngopharynx within a peak occurrence section on the swallowing signal were interpreted applying the following three steps: (1) peak classification, (2) reference point detection, and (3) laryngopharynx motion analysis. First, in the peak classification step, high and low peaks were defined by comparing amplitude, height of peak, among the occurred peaks as shown in Figure 5.3. Next, in the reference point detection step, starting point, peak, and ending point were determined by each peak occurrence section as shown in Figure 5.3. For example, six reference points (staring point, peak, ending point of high and low peaks) were determined when occurring two peaks. Lastly, in the laryngopharynx motion analysis step, the timing bar (Figure 5.4) of the analysis S/W was exactly matched into the reference point on the swallowing signal for capturing the corresponding VFSS image and then the movement of the laryngopharynx in the neighborhood of attachment site of the ultrasonic Doppler sensor was interpreted as shown in Figure 5.4.

Results

When occurring two peaks on the swallowing signal, the high peak and low peak corresponded with the ascending and descending movements of the laryngopharynx during

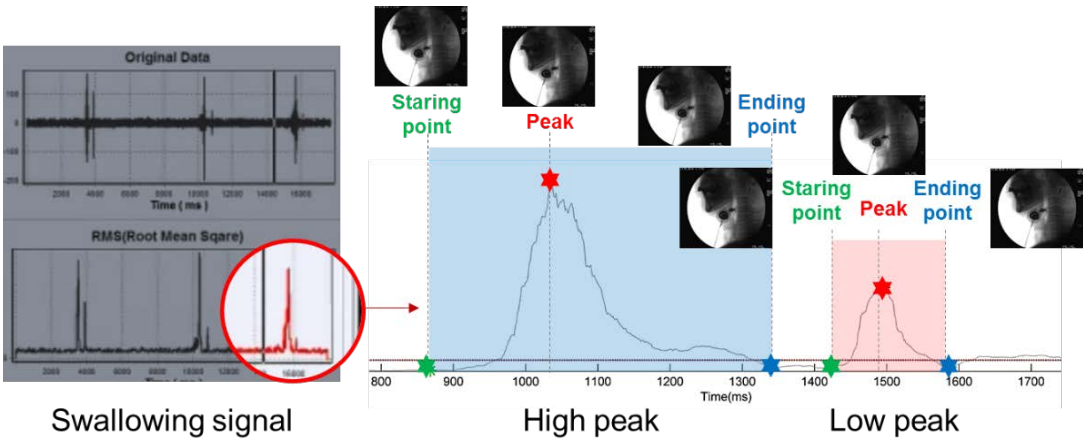


Figure 5.3. Classification of peaks and their reference points

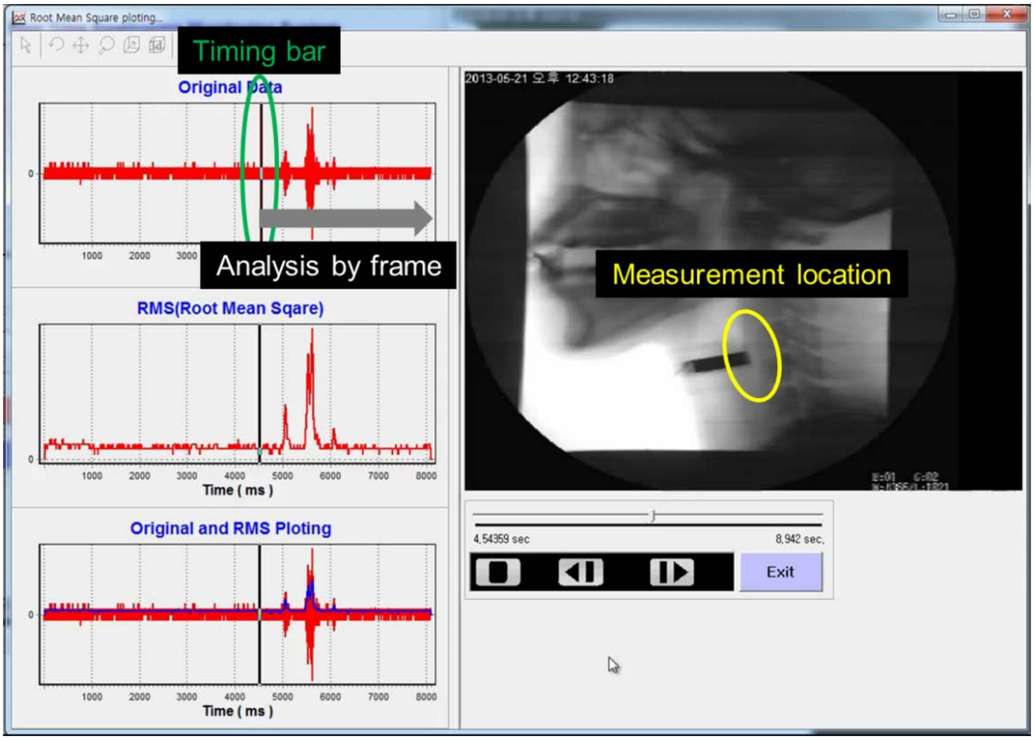


Figure 5.4. Synchronization of swallowing signal with laryngopharynx motion

swallowing, respectively. As shown in Figure 5.5, ascending movements of the laryngopharynx were observed in all the starting points, peaks, and ending points of the high peak occurrence section; while, descending movements in those of the low peak occurrence section. As a result of in-depth analysis, (1) starting point, (2) peak, and (3) ending point of the high peak occurrence section could be interpreted as initiation, development with maximum speed, and termination of ascending movements of the laryngopharynx, respectively, as shown in Figure 5.5; while, (4) starting point, (5) peak, and (6) ending point of the low peak occurrence section could be interpreted as initiation,

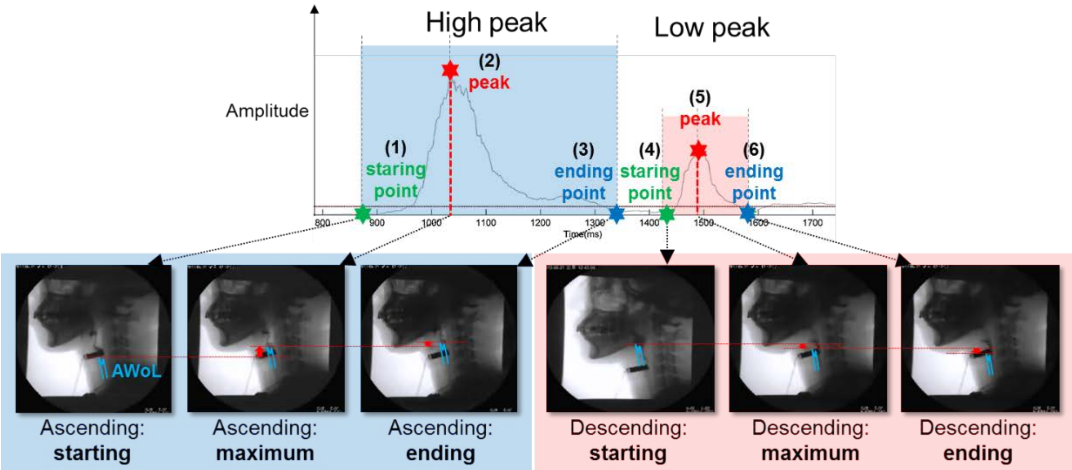


Figure 5.5. Meaning of staring point, peak, and ending point of high and low peaks (AWoL: anterior wall of laryngopharynx)

development with maximum speed, and termination of descending movements of the laryngopharynx, respectively, as shown in Figure 5.5. The present study found the pharyngeal shortening, which includes ascending motion of the pharynx to rapidly transport the bolus from the oral cavity to the esophagus (Ergun et al., 1993a; Ergun et al., 1993b) , was the reason why the peak for ascending movement of the laryngopharynx was higher compared to the peak for descending movement of the laryngopharynx, by observing the corresponding VFSS images. In addition, the present study marked the anterior wall of laryngopharynx (AWoL) on the VFSS image as shown in Figure 5.5 for visualizing the movement of the laryngopharynx. As a result of tracking the AWoL location, found that the bolus was passed from (2) peak of the high peak occurrence section to (5) peak of the low peak occurrence section.

When occurring three peaks on the swallowing signal, the first peak corresponded with the complex ascending and descending movements of the laryngopharynx caused by the soft palate elevation before pharyngeal swallowing and the second high peak and third low peak corresponded with the ascending and descending movements of the laryngopharynx, respectively, during pharyngeal swallowing. As shown in Figure 5.6, because the bolus was located in the oral cavity at (7) starting point, (8) peak, and (9) ending point of the first peak occurrence section, concluded that the first peak was occurred in the oral stage, which retains the bolus in the oral cavity, not the pharyngeal stage. In addition, found by in-depth VFSS video analysis that ascending and/or descending movements of the soft palate sometimes induce the corresponding directional movement of the laryngopharynx before the bolus was transported to the pharynx. As

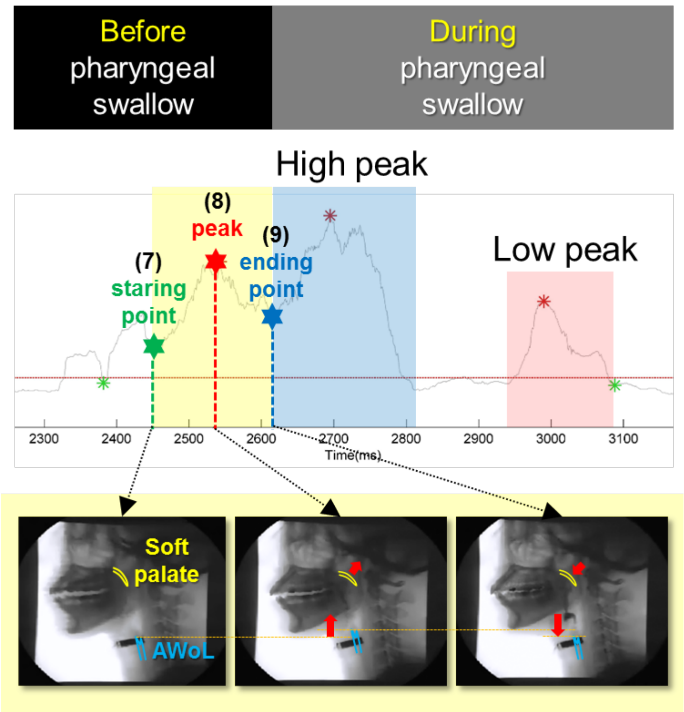


Figure 5.6. Meaning of first peak ahead of occurrence of high peak

shown in Figure 5.6, (7) starting point, (8) peak, and (9) ending point of the first peak occurrence section could be interpreted as initiation of ascending movements of the laryngopharynx, termination of ascending movements and initiation of descending movements of the laryngopharynx together, and termination of descending movements of the laryngopharynx, respectively. Remind that the subject experimented in the present study shows one three-peak swallowing before occurring the pharyngeal stage out of nine swallowing trails. Based on the aforementioned result, inferred that the swallowing strategy can be different each time.

5.3. Meaning of Swallowing Quantification Measures

Meanings of swallowing quantification measures (peak amplitude, duration time, number of peaks, peak-to-peak interval, and impulse) were established by VFSS analysis as presented in Figure 5.7. First, peak amplitude refers to the highest amplitude occurred in the pharyngeal stage; thus, is defined as the maximum instant movement of the laryngopharynx. Second, duration time refers to the swallowing duration time from initiation of the ascending movement of the laryngopharynx to termination of the descending movement of the laryngopharynx occurred in the pharyngeal stage; thus, is defined as the total movement time of the laryngopharynx. Third, number of peaks refers to the total occurrence number of maximum instant movements in each ascending or descending movement in the pharyngeal stage; thus, is defined as the number of movement types in the laryngopharynx. Forth, peak-to-peak interval refers to the transportation time

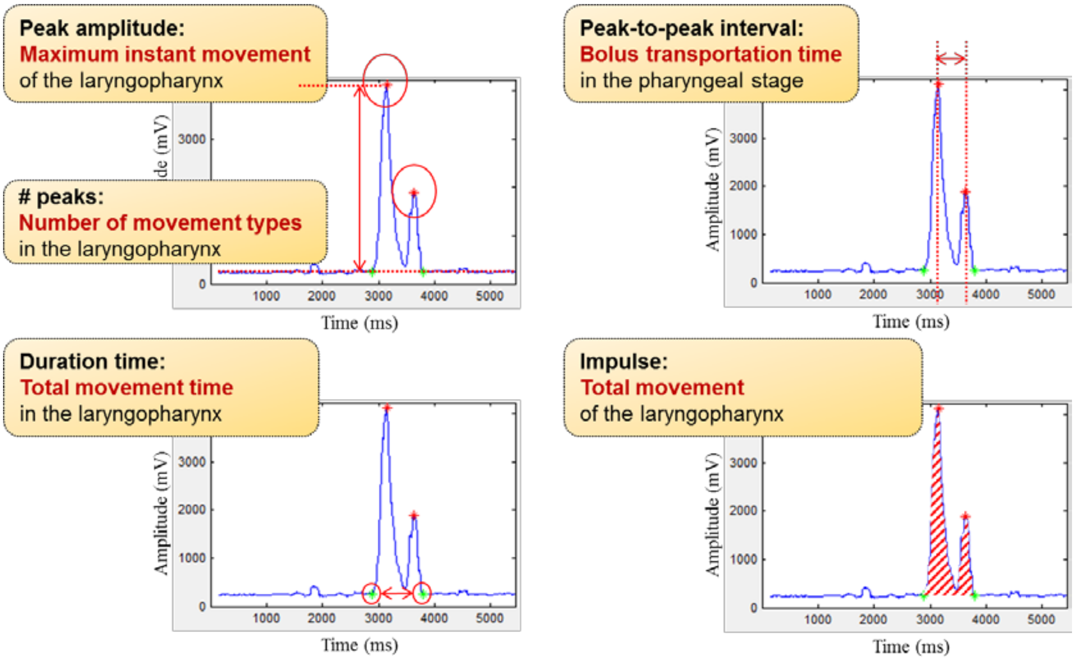


Figure 5.7. Meaning of swallowing quantification measures

of the bolus from the entrance of the pharyngeal (exit of the oral cavity) to the exit of the pharyngeal (entrance of the esophagus); thus, is defined as the bolus transportation time in the pharyngeal stage. Lastly, impulse refers to the total amount of movements from initiation of the ascending movement of the laryngopharynx to termination of the descending movement of the laryngopharynx occurred in the pharyngeal stage; thus, is defined as the total movement of the laryngopharynx.

Chapter 6 SWALLOWING EXPERIMENT

6.1. Participants

In the swallowing experiment, 120 healthy adults and 36 patients with dysphagia participated in their 20s to 70s as shown in Figure 5.1. The healthy adult group was composed of 10 males and females in each age group of 20s to 70s with no symptoms of dysphagia such as coughing, pain, and regurgitation (refer to Figure 2.9). The dysphagic patient group, who has been diagnosed with dysphagia at the Samsung Medical Center (Seoul, South Korea), was recruited on January to March, 2013 and that aged 20s could not be recruited due to absence on the corresponding period. Dysphagic patients showed that those of 94% (34/36) was more than 50s and female:male = 2:5. The swallowing experiment was conducted admitted by the Institutional Review Board (IRB) of the Samsung Medical Center and the Korea Food & Drug Administration (KFDA).

Table 6.1. Age and gender distribution of healthy adults and patients with dysphagia

	20s		30s		40s		50s		60s		70s ≤		Total	
	HA	DP	HA	DP	HA	DP	HA	DP	HA	DP	HA	DP	HA	DP
Female	10	-	10	1	10	-	10	1	10	1	10	7	60	10
Male	10	-	10	-	10	1	10	6	10	12	10	7	60	26
Total	20	-	20	1	20	1	20	7	20	13	20	14	120	36

Note. Healthy adults: HA; Dysphagic patients: DP

6.2. Apparatus

The swallowing measurement system (SMD) and swallowing measurement-related tools, as shown in Figure 6.1, were used in the swallowing experiment. The SMD, sensor cases, and a flexible band, developed by Lee, Jung, et al. (2012), were used for measuring coordination movements of the laryngopharynx during swallowing. Ultrasonic gels, uniformly spread on surface of the ultrasonic Doppler sensor, were used for minimizing the medium difference between the neck surface and ultrasonic Doppler sensor. A lemon image was shown to the subject for stimulating salivary secretion. Measuring cups and spoons were used for measuring swallowing volumes accurately. Water, plum juice, and

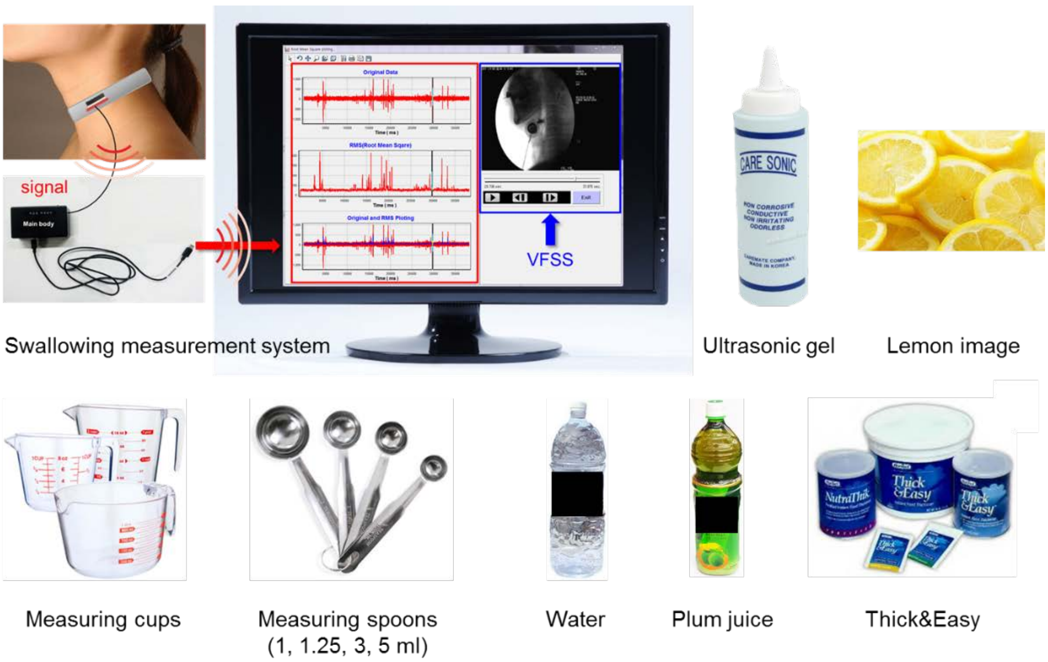


Figure 6.1. Apparatus for swallowing experiment

thickeners for dysphagic patients (Thick&Easy, Hormel Health Labs, USA) were used for making swallowing experimental conditions.

6.3. Experimental Procedure

The swallowing experiment was conducted by the following four steps lasting a total of 20 min as presented in Figure 6.2: introduction (3 min), exercise (5 min), swallowing session (7 min), and debriefing (5 min). In the introduction step, the purpose and procedure of the experiment were explained to the participant and written informed consent provided by the IRB was obtained. In the exercise step, an attachment site of the ultrasonic Doppler sensor was determined within the neck surface for making a swallowing signal detected well. As shown in Figure 6.3, the ultrasonic Doppler sensor was initially attached on the lateral border of the hyoid bone (no. 7 in Figure 6.3), which is on the wrinkle line through center of the hyoid bone, out of 24 attachment site candidates proposed by Takahashi, Michael, and Michi (1994) and then was finally fixed to the best attachment site at which peaks of the swallowing signal were clearly detected through iterative trials of moving upward/downward and leftward/rightward the sensor 1 ~ 2 mm swallowing water a little. In the swallowing session step, three repeated trials were randomly administered for seven experimental conditions such as dry saliva (DS), thin liquid (TN) 1, 3, 9 ml, thick liquid (TK) 1, 3, 9 ml (total 21 trials) with 5 seconds rest between the swallowing trials and 30 seconds rest after 7th and 14th swallowing trials (1/3 and 2/3 of total trials). Lastly, in the

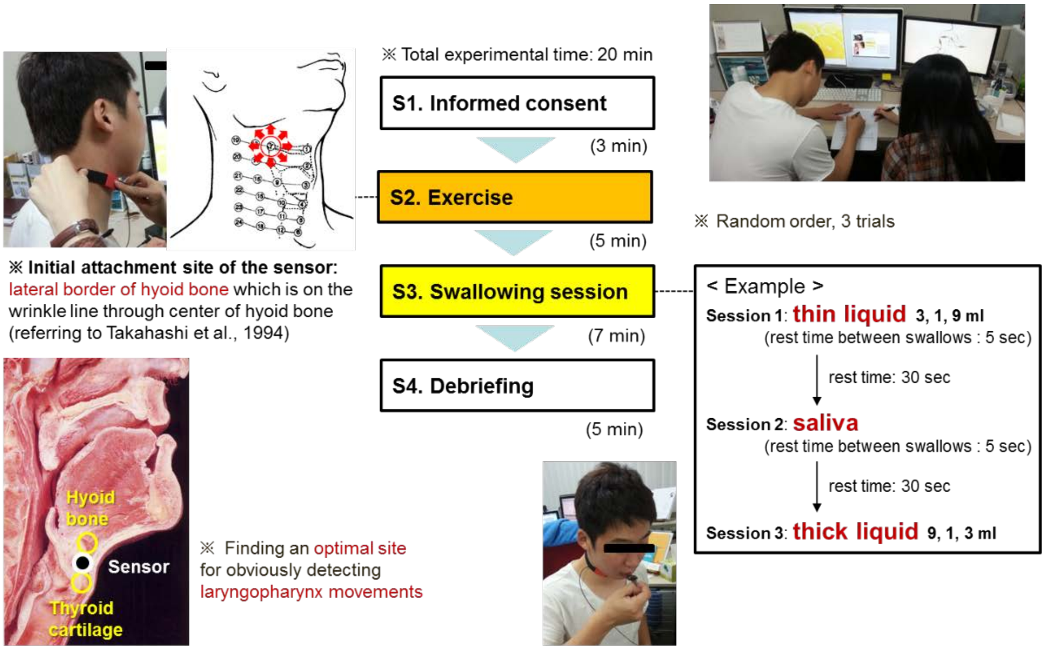


Figure 6.2. Procedure of swallowing experiment

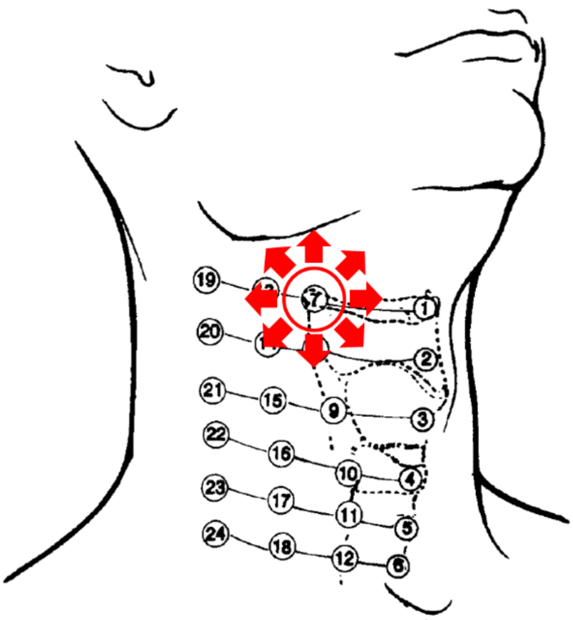


Figure 6.3. Attachment site candidates on the neck surface to detect movements of the laryngopharynx using ultrasonic Doppler sensor
(red circle: initial attachment site; adapted from Takahashi et al., 1994)

debriefing step, the trial not measured well was conducted again and a monetary compensation was provided for participation in the swallowing experiment.

6.4. Data Cleaning

Measurements of 5% were eliminated by two-step data cleaning using standard deviation (*SD*) and coefficient of variation (*CV*) for each swallowing quantification measure of each subject and eliminated. In the data cleaning step using *SD*, *M*s and *SD*s were calculated for the five swallowing quantification measures (peak amplitude, duration time, number of peaks, peak-to-peak interval, impulse) of the 120 healthy adults and 36 dysphagic patients and then measurements beyond corresponding $M \pm 2SD$ (Barnett & Lewis, 1994) for each participant have been regarded as outliers and removed (1st removal rate of data = 4%). In

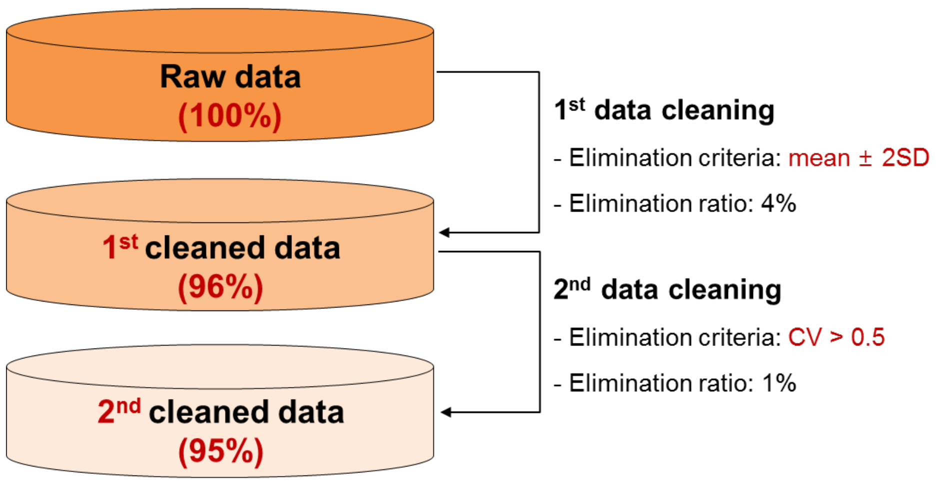


Figure 6.4. Data cleaning protocol
(total removal rate = 5%)

the data cleaning step using *CV*, one measurement having the lowest similarity among three measurements in each experimental condition were removed (2nd removal rate of data = 1%) for more data stabilization when *CV* > 0.5. A total of 5% measurements by swallowing quantification measure was eliminated.

Chapter 7 SWALLOWING ANALYSIS

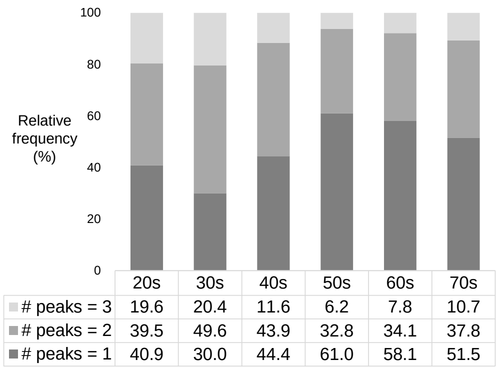
7.1. Analysis of Number of Peaks on Normal Swallow

Method

Relative frequency (%) of peaks occurred during swallowing was analyzed. Number of peaks on the swallowing signal of healthy adults (n = 120) during swallowing was calculated by age (20s to 70s), gender (male and female), swallowing food type (dry saliva, thin liquid, and thick liquid), and swallowing food volume (1, 3, and 9 ml). The χ^2-test was conducted at $\alpha = 0.05$ to analyze the effects of age, gender, swallowing food type, and swallowing food volume on number of peaks.

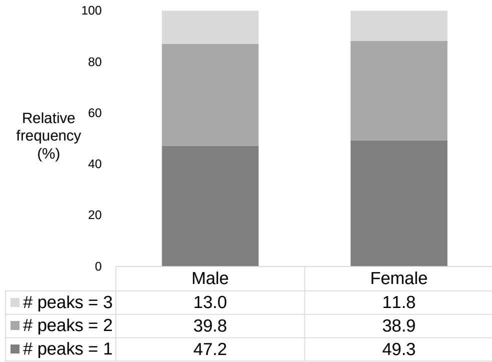
Results

The relative frequency of which number of peaks = 1 or 2 was 88% on normal swallow and only the effect of age was found significant on number of peaks. First, the relative frequency of peaks was dependent of the age group ($\chi^2[10] = 33.121$, $p < 0.001$) and relative frequencies of which number of peaks = 1 or 2 for 20s, 30s, 40s, 50s, 60s, and 70s were 81%, 80%, 88%, 94%, 92%, and 89%, respectively, as shown in Figure 7.1a. Second, the relative frequency of peaks was independent of the gender group and relative frequencies of which number of peaks = 1 or 2 for male and female were 87% and 88%, respectively, as shown in Figure 7.1b. Third, the relative frequency of peaks was independent of the swallowing food type and relative frequencies of which number of



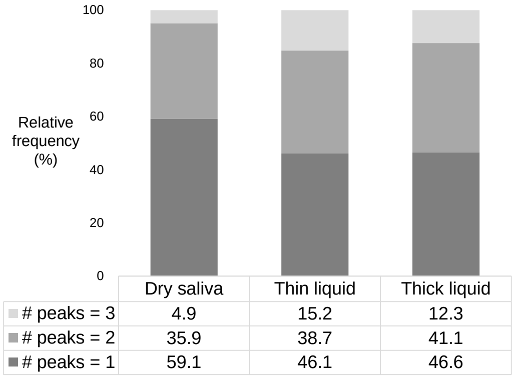
	20s	30s	40s	50s	60s	70s
# peaks = 3	19.6	20.4	11.6	6.2	7.8	10.7
# peaks = 2	39.5	49.6	43.9	32.8	34.1	37.8
# peaks = 1	40.9	30.0	44.4	61.0	58.1	51.5

(a) Age



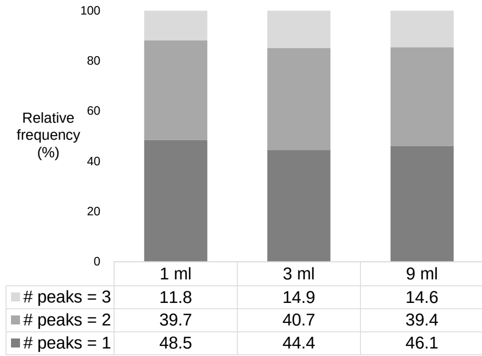
	Male	Female
# peaks = 3	13.0	11.8
# peaks = 2	39.8	38.9
# peaks = 1	47.2	49.3

(b) Gender



	Dry saliva	Thin liquid	Thick liquid
# peaks = 3	4.9	15.2	12.3
# peaks = 2	35.9	38.7	41.1
# peaks = 1	59.1	46.1	46.6

(c) Swallowing type



	1 ml	3 ml	9 ml
# peaks = 3	11.8	14.9	14.6
# peaks = 2	39.7	40.7	39.4
# peaks = 1	48.5	44.4	46.1

(d) Swallowing volume

Figure 7.1. Relative frequency (%) of number of peaks on normal swallowing signal

peaks = 1 or 2 for dry saliva, thin liquid, and thick liquid were 95%, 84%, and 88%, respectively, as shown in Figure 7.1c. Lastly, the relative frequency of peaks was independent of the swallowing food volume and relative frequencies of which number of peaks = 1 or 2 for 1 ml, 3ml, and 9 ml were 88%, 85%, and 85%, respectively, as shown in Figure 7.1d. As a result of observing movements of the hyoid bone and thyroid cartilage in the laryngopharynx during swallowing, found that ascending and descending movements of the laryngopharynx were overlapped due to occurring small time difference between them when number of peaks = 1 (49%); while, those were clearly separated due to occurring big time difference between them when number of peaks = 2 (39%).

7.2. Classification of Swallowing Types in Healthy Adults and Dysphagic Patients

Method

Swallowing signal types of healthy adults and dysphagic patients were identified respectively by clustering analysis. The *K*-means non-hierarchical clustering analysis was conducted to healthy adults (n = 120) and dysphagic patients (n = 36) using peak amplitude, duration time, and number of peaks out of the five swallowing quantification measures (peak amplitude, duration time, number of peaks, peak-to-peak interval, and impulse) as input variables. Peak-to-peak interval was not considered in the clustering analysis due to its absence when number of peaks = 1 and impulse due to its high correlation (r = 0.796, p < 0.001) with peak amplitude. Number of swallowing signal types, which corresponds *K* in the *K*-means non-hierarchical clustering analysis, was determined as three at which within-cluster average Euclidian distance was the smallest and between-cluster average Euclidian distance was the biggest out of K = 2 to 5. Representative swallowing signal types was selected as real cases having minimum Euclidian distance from the centroid of the generated cluster.

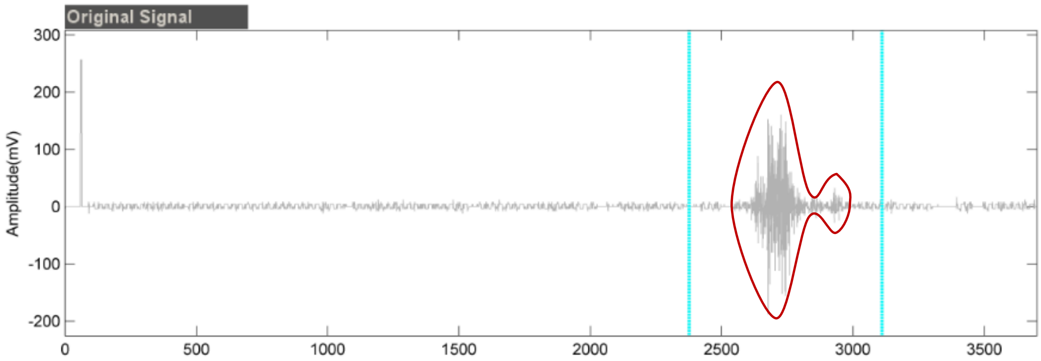
Results

The peak occurrence type of the swallowing signal was classified into short-double peak (Figure 7.2a), short-single peak (Figure 7.2b), and short-multiple peak (Figure 7.2c) for healthy adults and short-double peak (Figure 7.3a), long-double peak (Figure 7.3b), and long-multiple peak (Figure 7.3c) for dysphagic patients. In the peak occurrence type of healthy adults, 43% was categorized into the short-double peak type which includes 2 peaks and duration time < 1 s, 39% into the short-single peak type which includes 1 peak and duration time < 1 s, and 18% into the short-multiple peak type which includes more than 3 peaks and duration time < 1 s. Meanwhile, in the peak occurrence type of dysphagic patients, 19% was categorized into the short-single peak type as presented in the peak occurrence type of healthy adults, 65% into the long-double peak type which includes 2 peak and duration time ≥ 1 s, and 16% into the long-multiple peak type which includes more than 3 peaks and duration time ≥ 1 s.

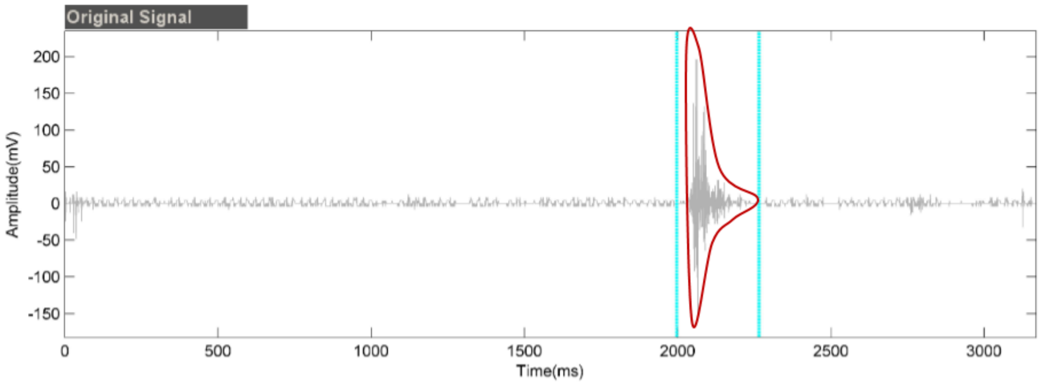
7.3. Effects of Age, Gender, Drinking Type, and Drinking Volume on Normal Swallow

Method

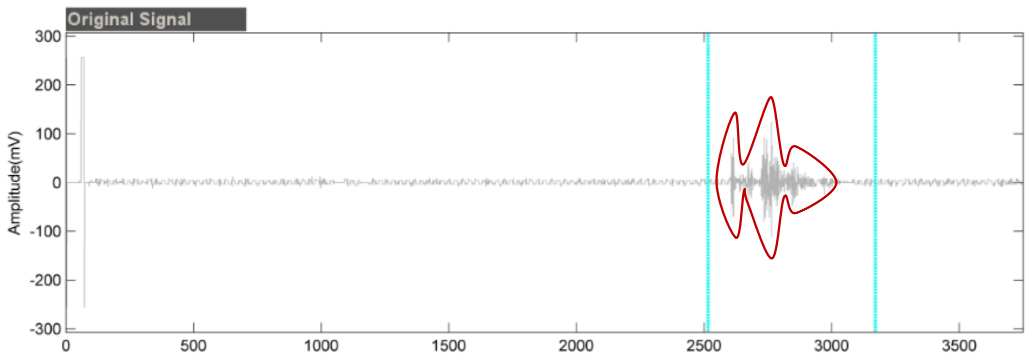
The effects of age, gender, swallowing food type, and swallowing food volume on normal swallow were analyzed. Five four-factor mixed-subjects ANOVAs for the swallowing quantification measures (peak amplitude, duration time, number of peaks, peak-to-peak interval, and impulse) were conducted at $\alpha = 0.05$ to examine the effect of age (20s to 70s; between-subject-factor), gender (male and female; between-subject-factor), swallowing



(a) Short-double peak: 43%

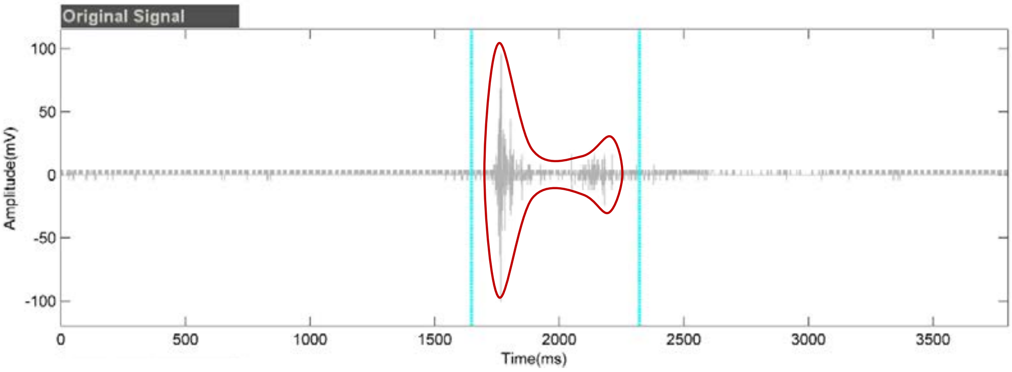


(b) Short-single peak: 39%

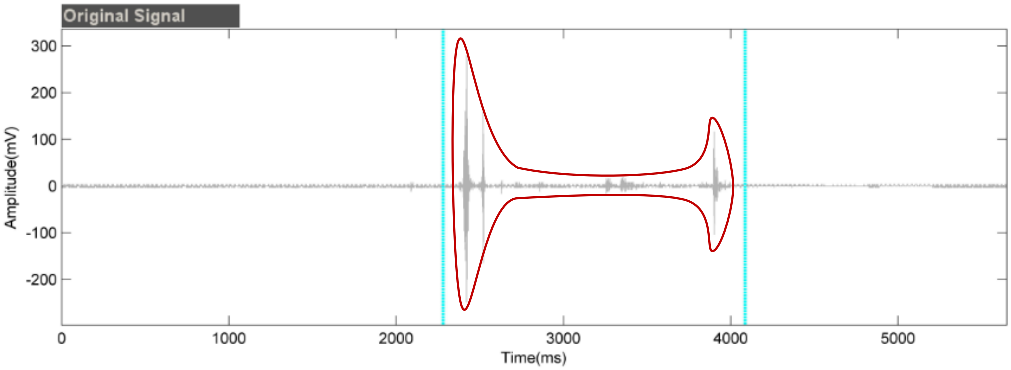


(c) Short-multiple peak: 18%

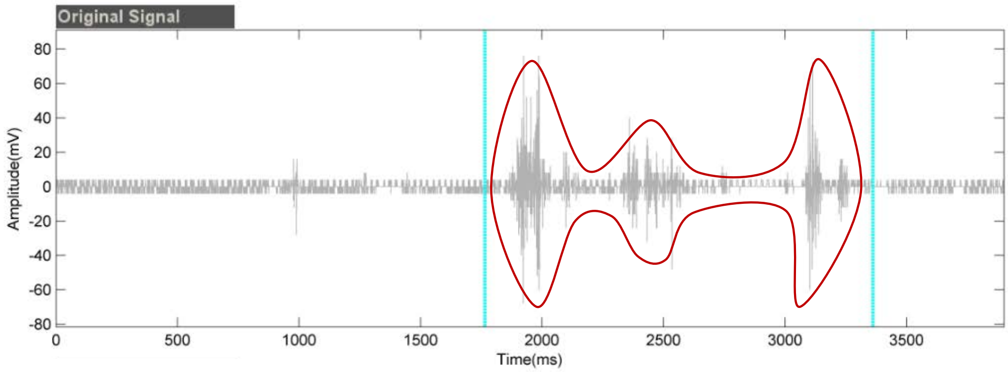
Figure 7.2. Representative swallowing signal types of healthy adults



(a) Short-double peak: 19%



(b) Long-double peak: 65%



(c) Long-multiple peak: 16%

Figure 7.3. Representative swallowing signal types of dysphagic patients

food type (thin liquid and thick liquid; within-subject-factor), and swallowing food volume (1 ml, 3 ml, and 9 ml; within-subject-factor) and interactions higher than two-way were assumed negligible due to difficulties in interpretation. As a measure in terms of peak amplitude, highest peak amplitude was used in the ANOVA to examine ascending movements of the laryngopharynx in the pharyngeal shortening. As a measure in terms of peak-to-peak interval, longest peak-to-peak interval was used in the ANOVA to examine difference between ascending and descending movements of the laryngopharynx when number of peaks was more than two. Lastly, measurements of swallowing thin liquid 1, 3, 9 ml and thick liquid 1, 3, 9 ml were normalized to the average measurement (normalized value = 100) of swallowing dry saliva three times because inter-subject variability of swallowing dry saliva was found high.

Results

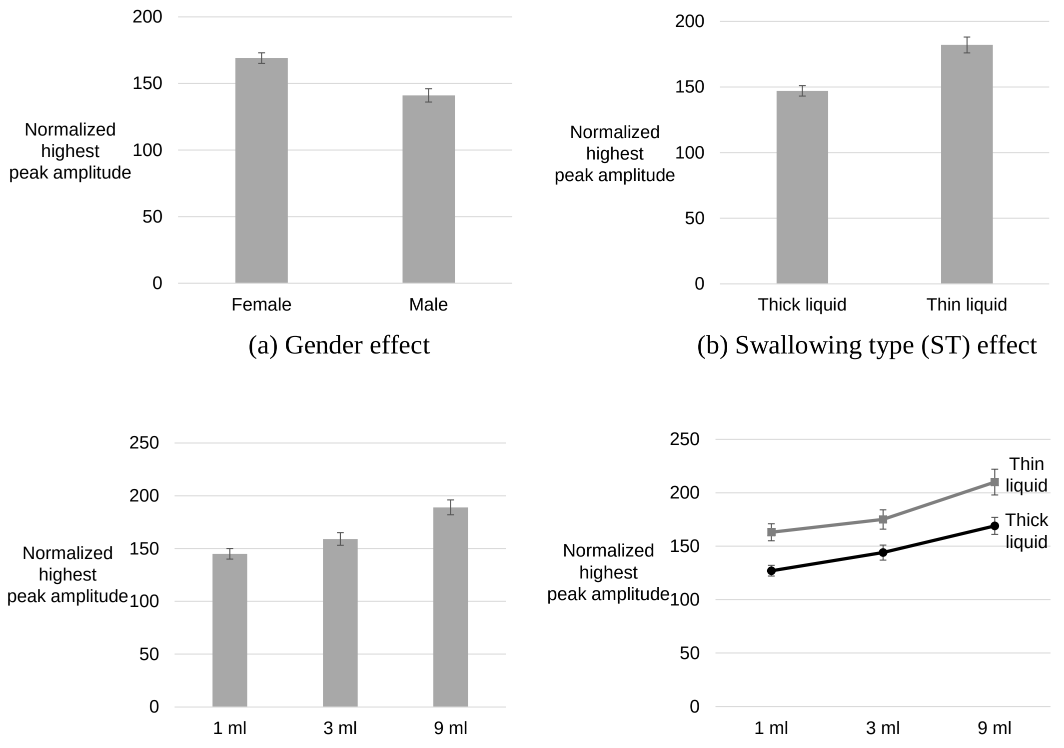
The effects of gender, swallowing food type, swallowing food volume and interaction between swallowing food type and volume were found significant on highest peak amplitude of healthy adults during swallowing (Table 7.1). First, maximum instant movement of the laryngopharynx of females (169 ± 100 mV) was significantly 20% higher compared to that of males (141 ± 73 mV) ($F[1, 108] = 4.80$, $p = 0.031$) as shown in Figure 7.4a. Second, maximum instant movement of the laryngopharynx during swallowing thin liquid (182 ± 104 mV) was significantly 24% higher compared to that during swallowing thick liquid (147 ± 75 mV) ($F[1, 113] = 10.31$, $p = 0.002$) as shown in Figure 7.4b. Third, maximum instant movement of the laryngopharynx during swallowing 9 ml (189 ± 106

Table 7.1. Summary of ANOVA results: age, gender, swallowing type, and swallowing volume effects on normal swallow

	Highest peak amplitude	Duration time	Number of peaks	Longest peak-to-peak interval	Impulse
Age (*A*)	▪ $F(5, 108) = 1.16$ ▪ $p = 0.333$	▪ $F(5, 108) = 0.82$ ▪ $p = 0.539$	▪ $F(5, 108) = 0.74$ ▪ $p = 0.592$	▪ $F(5, 108) = 0.85$ ▪ $p = 0.515$	▪ $F(5, 108) = 1.07$ ▪ $p = 0.384$
Gender (*G*)	▪ $F(1, 108) = 4.80$ ▪ $p = 0.031$	▪ $F(1, 108) = 0.47$ ▪ $p = 0.495$	▪ $F(1, 108) = 3.41$ ▪ $p = 0.068$	▪ $F(1, 108) = 0.09$ ▪ $p = 0.793$	▪ $F(1, 108) = 3.23$ ▪ $p = 0.075$
Swallowing food type (*SFT*)	▪ $F(1, 113) = 10.31$ ▪ $p = 0.002$	▪ $F(1, 113) = 0.49$ ▪ $p = 0.484$	▪ $F(1, 112) = 3.37$ ▪ $p = 0.069$	▪ $F(1, 57) = 0.47$ ▪ $p = 0.497$	▪ $F(1, 113) = 8.16$ ▪ $p = 0.005$
Swallowing food volume (*SFV*)	▪ $F(2, 225) = 5.79$ ▪ $p = 0.004$	▪ $F(2, 226) = 1.08$ ▪ $p = 0.342$	▪ $F(2, 225) = 1.58$ ▪ $p = 0.208$	▪ $F(2, 164) = 2.07$ ▪ $p = 0.129$	▪ $F(2, 225) = 8.34$ ▪ $p < 0.001$
$A \times G$	▪ $F(5, 108) = 0.80$ ▪ $p = 0.554$	▪ $F(5, 108) = 1.42$ ▪ $p = 0.221$	▪ $F(5, 108) = 0.75$ ▪ $p = 0.587$	▪ $F(5, 108) = 1.52$ ▪ $p = 0.189$	▪ $F(5, 108) = 0.88$ ▪ $p = 0.495$
$A \times SFT$	▪ $F(5, 113) = 0.98$ ▪ $p = 0.432$	▪ $F(5, 113) = 1.42$ ▪ $p = 0.224$	▪ $F(5, 112) = 0.72$ ▪ $p = 0.607$	▪ $F(10, 108) = 0.84$ ▪ $p = 0.530$	▪ $F(5, 113) = 1.08$ ▪ $p = 0.374$
$A \times SFV$	▪ $F(10, 225) = 1.42$ ▪ $p = 0.173$	▪ $F(10, 226) = 0.71$ ▪ $p = 0.717$	▪ $F(10, 225) = 0.83$ ▪ $p = 0.601$	▪ $F(10, 164) = 1.76$ ▪ $p = 0.073$	▪ $F(10, 225) = 0.90$ ▪ $p = 0.535$
$G \times SFT$	▪ $F(1, 113) = 2.47$ ▪ $p = 0.120$	▪ $F(1, 113) = 0.08$ ▪ $p = 0.783$	▪ $F(1, 112) = 3.20$ ▪ $p = 0.077$	▪ $F(1, 57) = 1.30$ ▪ $p = 0.260$	▪ $F(1, 113) = 1.13$ ▪ $p = 0.291$
$G \times SFV$	▪ $F(2, 225) = 1.70$ ▪ $p = 0.186$	▪ $F(2, 226) = 0.25$ ▪ $p = 0.777$	▪ $F(2, 225) = 1.56$ ▪ $p = 0.213$	▪ $F(2, 164) = 1.64$ ▪ $p = 0.196$	▪ $F(2, 225) = 1.17$ ▪ $p = 0.312$
$SFT \times SFV$	▪ $F(2, 228) = 3.43$ ▪ $p = 0.034$	▪ $F(2, 236) = 0.85$ ▪ $p = 0.428$	▪ $F(2, 233) = 1.45$ ▪ $p = 0.236$	▪ $F(2, 90) = 2.21$ ▪ $p = 0.116$	▪ $F(2, 225) = 3.15$ ▪ $p = 0.045$

*Shaded area: $p < 0.05$

mV) was significantly 39% and 19% higher compared to that during swallowing 1 ml (145 ± 75 mV) and 3 ml (159 ± 89 mV) and that of 3 ml was significantly 10% higher compared to that during 1 ml (F[2, 225] = 5.79, p = 0.004) as shown in Figure 7.4c. Lastly, the interaction effect between swallowing food type and volume on maximum instant



(a) Gender effect

(b) Swallowing type (ST) effect

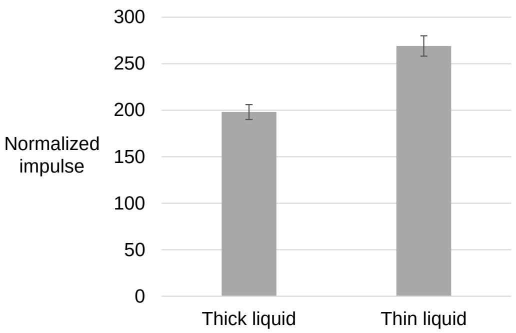
(c) Swallowing volume (SV) effect

(d) Interaction between ST and SV

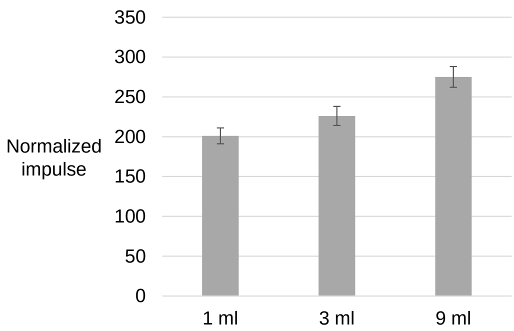
Figure 7.4. Peak amplitude during swallowing in healthy adults (mean ± SE)

movement of the laryngopharynx was found significant (F[2, 228] = 3.43, p = 0.034), and maximum instant movement of the laryngopharynx during swallowing thin liquid was high than that during thick liquid in all swallowing volume (1, 3, and 9 ml) as shown in Figure 7.4d.

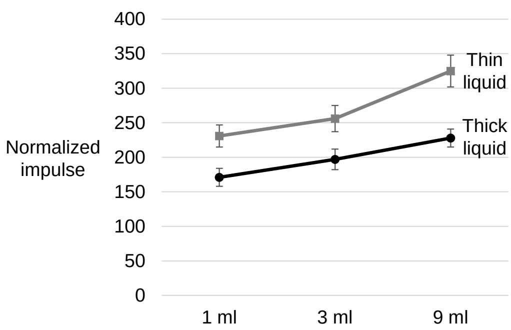
The effects of swallowing food type, swallowing food volume, and their interaction were found significant on impulse of healthy adults during swallowing (Table 7.1). First, total movement of the laryngopharynx during swallowing thin liquid (269 ± 210 mV × ms) was significantly 36% higher compared to that during swallowing thick liquid (198 ± 146 mV × ms) (F[1, 113] = 8.16, p = 0.005) as shown in Figure 7.5a. Second, total movement of the laryngopharynx during swallowing 9 ml (275 ± 200 mV × ms) was significantly 37% and 22% higher compared to that during swallowing 1 ml (201 ± 160 mV × ms) and 3 ml (226 ± 183 mV × ms) and that of 3 ml was significantly 12% higher compared to that during 1 ml (F[2, 225] = 5.79, p = 0.004) as shown in Figure 7.5b. Lastly, the interaction effect between swallowing food type and volume on total movement of the laryngopharynx was found significant (F[2, 225] = 3.15, p = 0.045), and total movement of



(a) Swallowing type (ST) effect



(b) Swallowing volume (SV) effect



(c) Interaction between ST and SV

Figure 7.5. Impulse during swallowing in healthy adults (mean ± SE)

the laryngopharynx during swallowing thin liquid was high than that during thick liquid in all swallowing volume (1, 3, and 9 ml) as shown in Figure 7.5c.

7.4. Comparison of Swallowing in Dysphagic Patients with Healthy Adults

Method

Swallowing capabilities of dysphagic patients were compared to those of healthy adults. The *t*-test was conducted at $\alpha = 0.05$ by swallowing quantification measure (peak amplitude, duration time, number of peaks, peak-to-peak interval, impulse) to examine that the means of dysphagic patients ($n = 36$) and healthy adults ($n = 120$) were significantly different. As a measure in terms of peak amplitude, highest peak amplitude was used in the analysis to examine ascending movements of the laryngopharynx in the pharyngeal shortening. As a measure in terms of peak-to-peak interval, first peak-to-last peak interval was used in the analysis to examine total bolus transportation time in the pharynx when number of peaks was more than two. Meanwhile, measurements of dysphagic patients ($n = 36$) during swallowing thin and thick liquids 9 ml were not acquired due to clinical hazard provided by a dysphagic expert. Therefore, the *t*-test was conducted in terms of five swallowing conditions such as dry saliva (DS), thick liquid (TK) 1, 3 ml, and thin liquid (TN) 1, 3 ml for healthy adults and dysphagic patients.

Results

Dysphagic patients showed significantly lower highest peak amplitude in all swallowing conditions (DS, TK 1 ml, TK 3 ml, TN 1 ml, TN 3 ml) compared to healthy adults as shown in Figure 7.6. In swallowing DS, highest peak amplitude (14.4 ± 8.9 mV) of dysphagic patients was significantly 3/20 times lower than that (17.0 ± 11.8 mV) of healthy adults ($t[180] = 2.29$, $p = 0.023$). In swallowing TK 1 ml, highest peak amplitude (15.7 ± 9.8 mV) of dysphagic patients was significantly 1/5 times lower than that (19.5 ± 13.6 mV) of healthy adults ($t[216] = 3.08$, $p = 0.002$). In swallowing TK 3 ml, highest peak amplitude (16.1 ± 9.9 mV) of dysphagic patients was significantly 1/4 times lower than that (21.0 ± 13.7 mV) of healthy adults ($t[173] = 3.85$, $p < 0.001$). In swallowing TN 1 ml, highest peak amplitude (15.9 ± 10.1 mV) of dysphagic patients was significantly 1/3 times lower than that (24.3 ± 15.9 mV) of healthy adults ($t[235] = 6.25$, $p < 0.001$). In

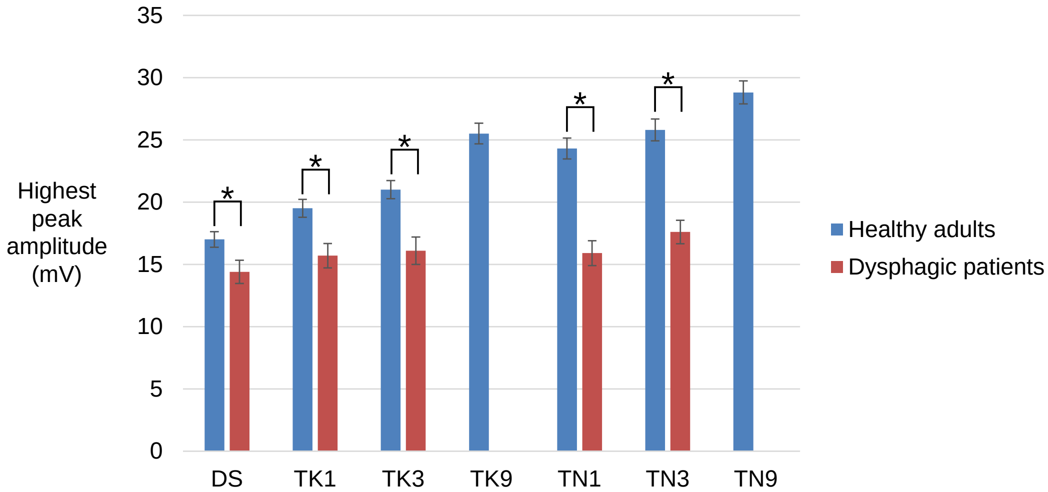


Figure 7.6. Mean comparison of highest peak amplitude in healthy adults vs. dysphagic patients (mean ± SE; *$p < 0.05$)

swallowing TN 3 ml, highest peak amplitude (15.9 ± 10.1 mV) of dysphagic patients was significantly 7/10 times lower than that (25.8 ± 16.4 mV) of healthy adults (t[268] = 6.639, $p < 0.001$). Lastly, in terms of all swallowing conditions (DS, TK 1 ml, TK 3 ml, TN 1 ml, TN 3 ml), highest peak amplitude (16.0 ± 9.57 mV) of dysphagic patients was significantly 3/10 times lower than that (23.1 ± 15.4 mV) of healthy adults (t[982] = 13.13, $p < 0.001$).

Dysphagic patients showed significantly longer duration time in all swallowing conditions (DS, TK 1 ml, TK 3 ml, TN 1 ml, TN 3 ml) compared to healthy adults as shown in Figure 7.7. In swallowing DS, duration time (882 ± 377 ms) of dysphagic patients was significantly 3 times longer than that (293 ± 174 ms) of healthy adults (t[109] = -15.09, $p < 0.001$). In swallowing TK 1 ml, duration time (922 ± 376 ms) of dysphagic patients was significantly 2.5 times longer than that (363 ± 186 ms) of healthy adults

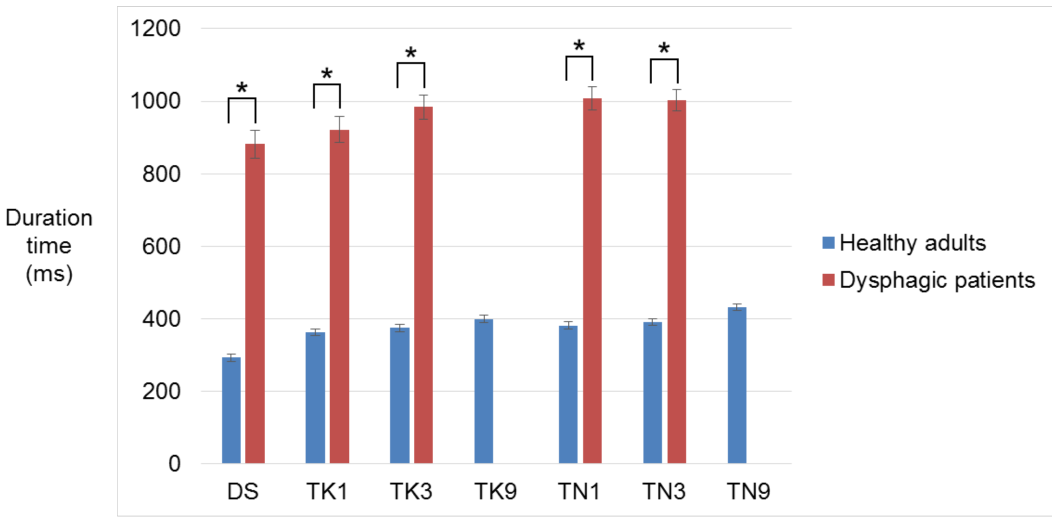


Figure 7.7. Mean comparison of duration time in healthy adults vs. dysphagic patients (mean ± SE; *$p < 0.05$)

($t[120] = -14.78$, $p < 0.001$). In swallowing TK 3 ml, duration time (984 ± 337 ms) of dysphagic patients was significantly 2.6 times longer than that (375 ± 187 ms) of healthy adults ($t[111] = -17.00$, $p < 0.001$). In swallowing TN 1 ml, duration time (1,008 ± 317 ms) of dysphagic patients was significantly 2.6 times longer than that (382 ± 176 ms) of healthy adults ($t[126] = -19.51$, $p < 0.001$). In swallowing TN 3 ml, duration time (1,002 ± 297 ms) of dysphagic patients was significantly 2.6 times longer than that (391 ± 169 ms) of healthy adults ($t[121] = -19.86$, $p < 0.001$). Lastly, in terms of all swallowing conditions (DS, TK 1 ml, TK 3 ml, TN 1 ml, TN 3 ml), duration time (960 ± 344 ms) of dysphagic patients was significantly 2.6 times longer than that (376 ± 182 ms) of healthy adults ($t[569] = -37.22$, $p < 0.001$).

Dysphagic patients showed significantly higher number of peaks in all swallowing conditions (DS, TK 1 ml, TK 3 ml, TN 1 ml, TN 3 ml) compared to healthy adults as shown in Figure 7.8. In swallowing DS, number of peaks (2.5 ± 0.9) of dysphagic patients was significantly 1.7 times longer than that (1.5 ± 0.6) of healthy adults ($t[126] = -11.46$, $p < 0.001$). In swallowing TK 1 ml, number of peaks (2.6 ± 0.9) of dysphagic patients was significantly 1.5 times longer than that (1.7 ± 0.7) of healthy adults ($t[134] = -10.39$, $p < 0.001$). In swallowing TK 3 ml, number of peaks (2.8 ± 0.8) of dysphagic patients was significantly 1.6 times longer than that (1.7 ± 0.7) of healthy adults ($t[131] = -12.26$, $p < 0.001$). In swallowing TN 1 ml, number of peaks (2.9 ± 0.7) of dysphagic patients was significantly 1.8 times longer than that (1.6 ± 0.7) of healthy adults ($t[147] = -14.83$, $p < 0.001$). In swallowing TN 3 ml, number of peaks (2.9 ± 0.8) of dysphagic patients was

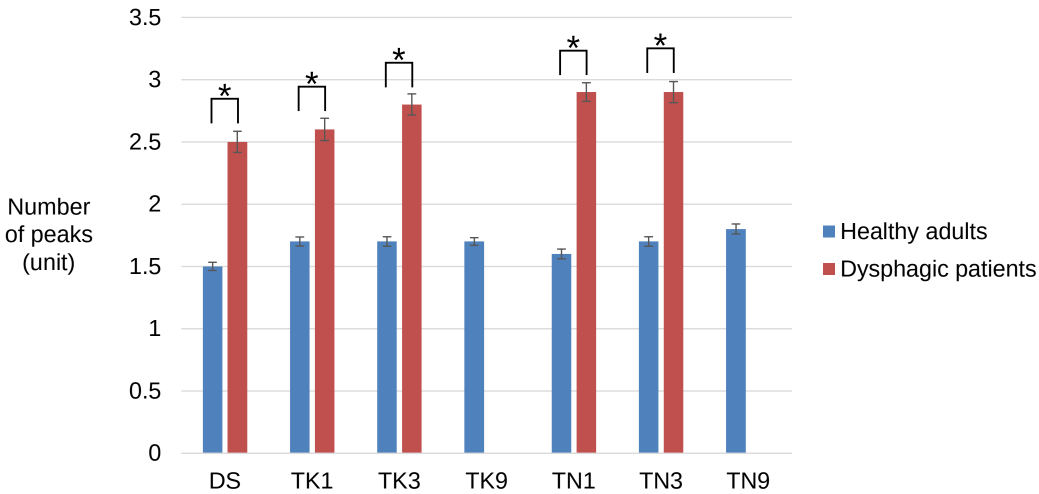


Figure 7.8. Mean comparison of number of peaks in healthy adults vs. dysphagic patients (mean ± SE; *$p < 0.05$)

significantly 1.7 times longer than that (1.7 ± 0.7) of healthy adults ($t[127] = -12.37$, $p < 0.001$). Lastly, in terms of all swallowing conditions (DS, TK 1 ml, TK 3 ml, TN 1 ml, TN 3 ml), number of peaks (2.8 ± 0.8) of dysphagic patients was significantly 1.7 times longer than that (1.7 ± 0.7) of healthy adults ($t[617] = -26.70$, $p < 0.001$).

Dysphagic patients showed significantly longer first peak-to-last peak interval in all swallowing conditions (DS, TK 1 ml, TK 3 ml, TN 1 ml, TN 3 ml) compared to healthy adults as shown in Figure 7.9. In swallowing DS, first peak-to-last peak interval (576 ± 295 ms) of dysphagic patients was significantly 6.3 times longer than that (92 ± 152 ms) of healthy adults ($t[116] = -15.99$, $p < 0.001$). In swallowing TK 1 ml, first peak-to-last peak interval (559 ± 273 ms) of dysphagic patients was significantly 3.8 times longer than that (147 ± 185 ms) of healthy adults ($t[137] = -14.68$, $p < 0.001$). In

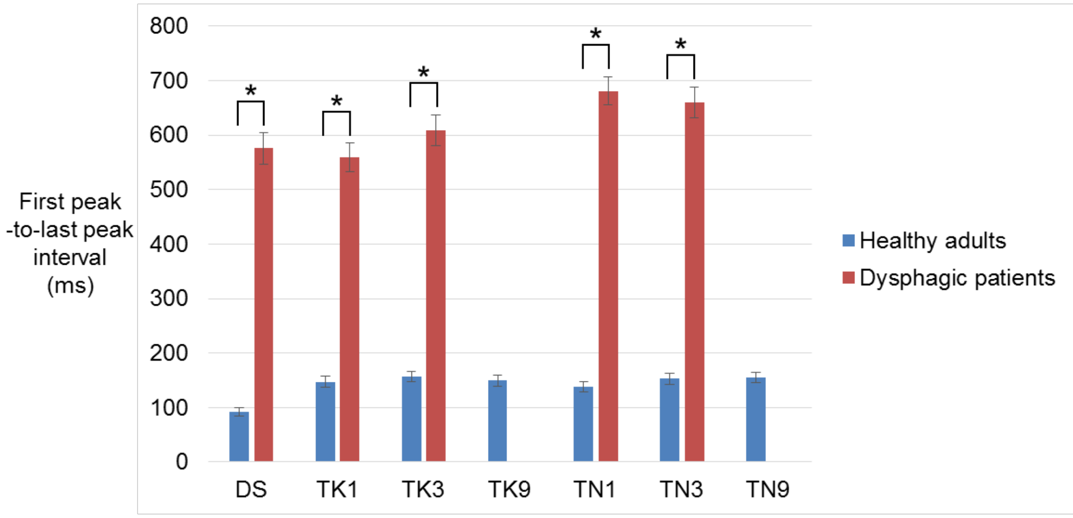


Figure 7.9. Mean comparison of first peak-to-last peak interval in healthy adults vs. dysphagic patients (mean ± SE; *$p < 0.05$)

swallowing TK 3 ml, first peak-to-last peak interval (609 ± 281 ms) of dysphagic patients was significantly 3.9 times longer than that (157 ± 192 ms) of healthy adults ($t[129] = -15.28$, $p < 0.001$). In swallowing TN 1 ml, first peak-to-last peak interval (681 ± 267 ms) of dysphagic patients was significantly 4.9 times longer than that (138 ± 186 ms) of healthy adults ($t[139] = -19.77$, $p < 0.001$). In swallowing TN 3 ml, first peak-to-last peak interval (660 ± 286 ms) of dysphagic patients was significantly 4.3 times longer than that (153 ± 188 ms) of healthy adults ($t[131] = -17.08$, $p < 0.001$). In terms of all swallowing conditions (DS, TK 1 ml, TK 3 ml, TN 1 ml, TN 3 ml), first peak-to-last peak interval (617 ± 283 ms) of dysphagic patients was significantly 4.3 times longer than that (142 ± 184 ms) of healthy adults ($t[618] = -36.89$, $p < 0.001$).

Dysphagic patients showed significantly lower impulse in swallowing TK 1 ml, TN 1 ml, and TN 3 ml compared to healthy adults as shown in Figure 7.10. In swallowing DS, impulse (2,599 ± 1,797 ms × mV) of dysphagic patients was not different with that (2,380 ± 1,769 ms × mV) of healthy adults. In swallowing TK 1 ml, impulse (2,662 ± 1,746 ms × mV) of dysphagic patients was significantly 3/20 times lower than that (3,151 ± 2,278 ms × mV) of healthy adults ($t[220] = 2.35$, $p = 0.019$). In swallowing TK 3 ml, impulse (3,233 ± 2,063 ms × mV) of dysphagic patients was not different with that (3,517 ± 2,459 ms × mV) of healthy adults. In swallowing TN 1 ml, impulse (3,209 ± 1,981 ms × mV) of dysphagic patients was significantly 1/5 times lower than that (4,006 ± 2,608 ms × mV) of healthy adults ($t[204] = 3.31$, $p = 0.001$). In swallowing TN 3 ml, impulse (3,669 ± 1,791 ms × mV) of dysphagic patients was significantly 1/5 times lower than that (4,463 ± 2,898

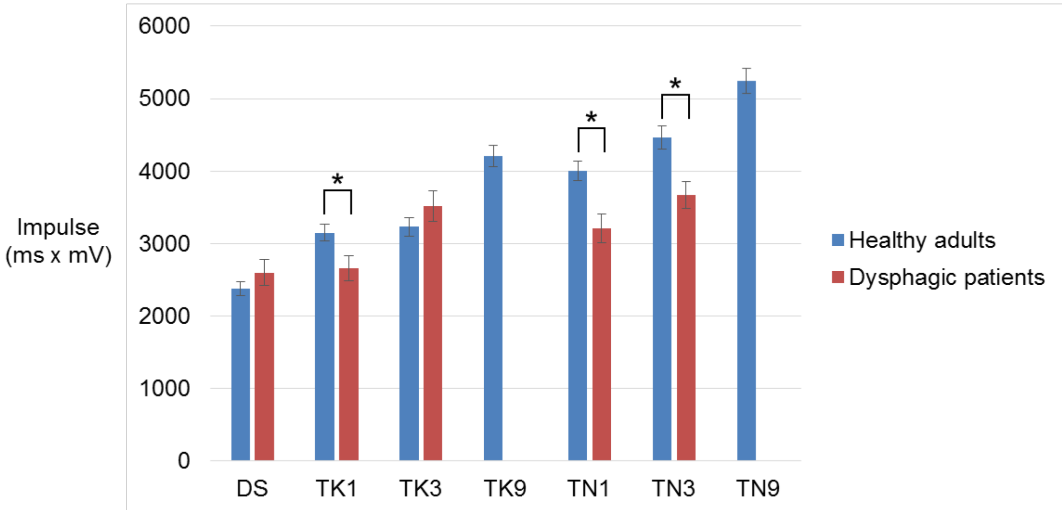


Figure 7.10. Mean comparison of impulse in healthy adults vs. dysphagic patients (mean ± SE; $*p < 0.05$)

ms × mV) of healthy adults ($t[245] = 3.31$, $p = 0.001$). In terms of swallowing all swallowing conditions (DS, TK 1 ml, TK 3 ml, TN 1 ml, TN 3 ml), impulse (3,063 ± 1,911 ms × mV) of dysphagic patients was significantly 1/5 times lower than that (3,835 ± 2,700 ms × mV) of healthy adults ($t[940] = 5.72$, $p < 0.001$).

7.5. Establishment of normative data of swallowing

To evaluate the swallowing of an individual and screen patients with dysphagia, normative data (*M*, *SD*, 5th percentile, and 95th percentile) of swallowing are established as presented in Table 7.2 by swallowing food type and swallowing food volume.

Table 7.2. Normative data of swallowing by swallowing food type and volume (DS: dry saliva, TK: thick liquid, TN: thin liquid)

Swallowing food and volume	DS	TK 1 ml	TK 3 ml	TK 9 ml	TN 1 ml	TN 3 ml	TN 9 ml
Highest peak amplitude (mV)							
M	16.1	18.4	20.4	23.7	22.7	23.8	25.7
SD	10.0	11.4	12.5	12.9	13.6	13.6	12.9
5^{th} %ile	5.6	6.8	6.6	7.6	6.8	8.5	8.8
95^{th} %ile	37.2	41.9	46.9	48.1	51.5	52.4	50.7
Duration time (ms)							
M	293	363	375	400	382	391	432
SD	174	186	187	186	176	169	163
5^{th} %ile	97	117	128	134	154	144	191
95^{th} %ile	664	751	751	749	743	720	755
Number of peaks (unit)							
M	1.5	1.7	1.7	1.7	1.6	1.7	1.8
SD	0.6	0.7	0.7	0.7	0.7	0.7	0.7
5^{th} %ile	1.0	1.0	1.0	1.0	1.0	1.0	1.0
95^{th} %ile	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Longest peak-to-peak interval (ms)							
M	231	266	264	269	254	237	229
SD	138	145	149	148	146	150	147
5^{th} %ile	62	79	72	89	76	55	68
95^{th} %ile	501	554	538	565	526	530	536
Impulse (ms × mV)							
M	2,380	3,055	3,399	4,052	3,788	4,063	4,664
SD	1,769	2,101	2,260	2,470	2,293	2,426	2,425
5^{th} %ile	486	628	670	1,038	988	883	1,276
95^{th} %ile	5,978	7,592	8,056	9,209	8,276	8,964	9,089

Chapter 8 DIAGNOSTIC MODEL FOR DYSPAGIA

Diagnostic models were developed for discriminating statistically the severity of dysphagia using a laryngopharyngeal movement signal measured by the ultrasonic Doppler sensor during swallowing (Figure 8.1). An optimal diagnostic model was determined out of various models with different swallowing liquid type and volume by comparing discriminant performances and practicality in clinic.

8.1. Statistical Method

Cumulative *logit* models were developed to discriminate the dysphagic severity evaluated by dysphagic experts using VFSS video during swallowing into three ordinal categories (normal, mild, and moderate/severe). The dysphagic severity of 120 healthy adults was classified into normal and that of 36 dysphagic patients was diagnosed into mild or

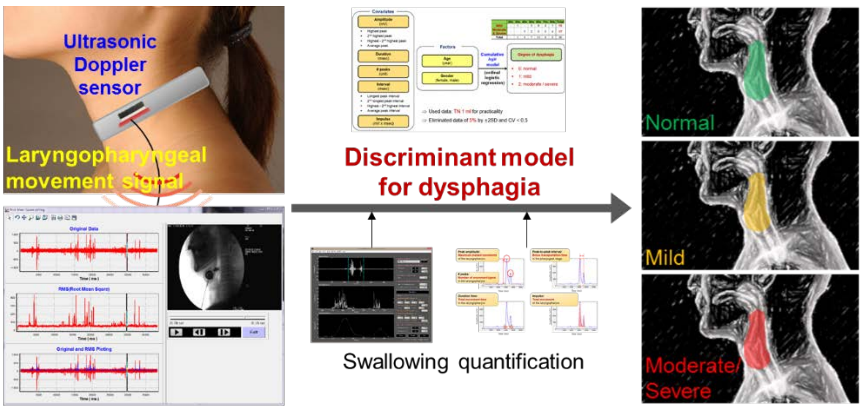


Figure 8.1. Big picture of diagnostic model for dysphagia

moderate/severe by two experts of dysphagia considering VFSS video evaluation results of a pharyngeal stage dysfunction rating scale and overall patient condition during swallowing. The pharyngeal stage dysfunction rating scale improving the dysphagia severity scale (O'Neil, Purdy, Falk, & Gallo, 1999) evaluates nine pharyngeal dysfunctions (velar elevation, hyo-laryngeal excursion, epiglottis inversion, upper esophageal sphincter opening, pharyngeal peristalsis, vallecular residue, pyriform sinus residue, delayed swallow reflex, and penetration/aspiration) out of three swallow phases (oral, pharyngeal, and esophageal phases) as shown in Figure 8.2 and its higher score means more severe (0 point: normal) as presented in Table 8.1. As a result of classifying dysphagic severity to 36 dysphagic patients (Table 8.2), number of dysphagic patients was 19 for mild and 13 for moderate/severe, but 4 for mild to moderate/severe due to difficulty to classify clearly dysphagic severity based on VFSS video evaluation. Meanwhile, more than moderate was

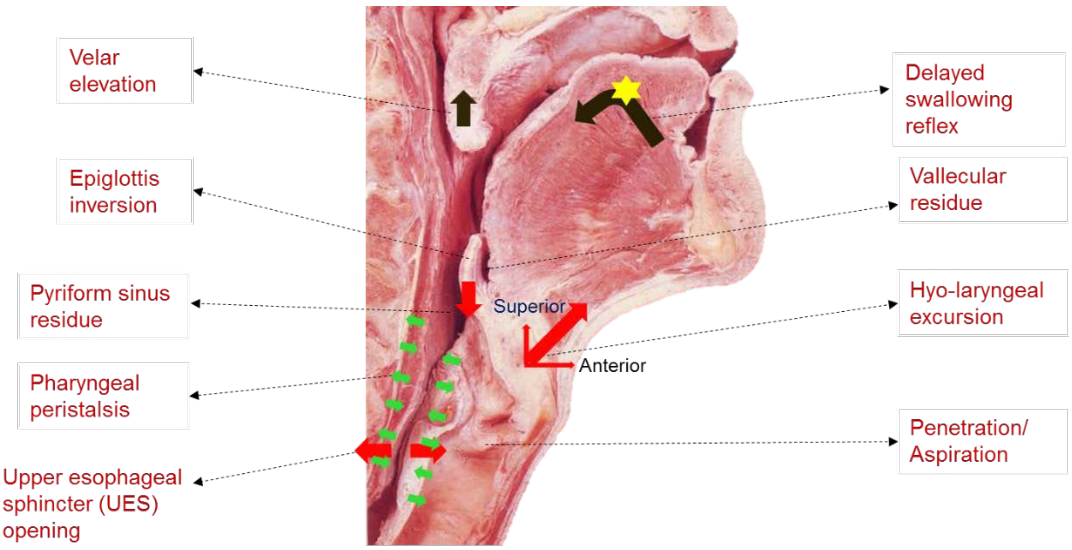


Figure 8.2. Pharyngeal stage dysfunctions

Table 8.1. Pharyngeal stage dysfunction rating scale

No.	Pharyngeal dysfunction	Score	Description
1	Velar elevation	0	complete velopharynx closure
		1	complete velopharynx closure but weak
		2	velopharynx closure present with nasal reflux
		3	inadequate velopharynx closure and/or severe degree of nasal reflux
2	Hyo-laryngeal excursion	0	normal
		1	mild (visible superior and anterior movement but mildly reduced range of movement)
		2	moderate (visible superior and anterior movement prominently reduced range of movement)
		3	severe (superior or anterior movement only or almost no movement at all)
3	Epiglottic inversion	0	normal
		1	mild (almost full range of movement but rigid or mild to moderately decreased inversion in liquid but normal inversion in solid food)
		2	moderate (reduced inversion, moving only halfway to 1/3 or the full range in both liquid and solid food)
		3	severe (no epiglottic inversion in thin liquid but may show partial inversion in semi-solid food or no inversion in all substances)
4	UES opening	0	normal
		1	prominently reduced opening range (only small amount enters the esophagus)
		2	almost unable to open UES (only a slight trace or no bolus enters the UES)
5	Pharyngeal peristalsis	0	none or slight trace of residue on the posterior pharyngeal wall
		1	prominent trace of residue on the posterior pharyngeal wall
		2	overall pharynx filled with residue
6	Vallecular residue	0	normal or slight trace of residue
		1	less than 25 percent of residue in the vallecular space
		2	ranging from over 25% to less than 50 percent of residue in the vallecular space
		3	over 50 percent of residue in the vallecular space
7	Pyriform sinus residue	0	normal or slight trace of residue
		1	less than 25 percent of residue in the pyriform sinus space
		2	ranging from over 25% to less than 50 percent of residue in the pyriform sinus
		3	over 50 percent of residue in the pyriform sinus
8	Delayed swallow reflex	0	less than 0.71 sec, 1.17 sec
		1	over 0.71 sec, 1.17 sec
		2	over 5 sec
9	Penetration /Aspiration	0	no penetration/aspiration
		1	material enters the airway, remains above the vocal folds, self-expectoration possible
		2	material enters the airway, remains above the vocal folds, self-expectoration impossible
		3	material enters the airway, contacts the vocal folds, and is not ejected from the airway
		4	material enters the airway, contacts the vocal folds, and is not ejected from the airway
		5	material enters the airway, passes below the vocal folds, and is ejected into the larynx or out of the airway
		6	material enters the airway, passes below the vocal folds, and is not ejected from the trachea despite effort
		7	material enters the airway, passes below the vocal folds, and no effort is made to eject

Table 8.2. Pharyngeal stage dysfunction rating result evaluated by clinicians using VFSS video during swallowing thin and thick liquids

Dysphagic patient	No.	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12
	Age (yrs)	62	70	67	58	80	74	57	31	80	76	84	63
	Gender	M	F	M	M	F	M	F	F	F	M	M	M
Velar elevation (max: 3)		0	0	0	0	0	0	0	0	0	0	0	1
Hyo-laryngeal excursion (3)		0	0	0	1	1	0	0	0	1	1	2	2
Epiglottic inversion (3)		1	1	1	3	2	1	0	1	2	3	3	2
UES opening (2)		0	0	0	1	0	0	0	1	1	1	1	0
Pharyngeal peristalsis (2)		0	0	0	0	0	0	0	0	0	1	1	0
Vallecular residue (3)		1	1	2	2	1	1	0	1	0	2	4	1
Pyriform sinus residue (3)		1	1	2	1	1	0	0	0	0	1	3	0
Delayed swallow reflex (2)		0	0	2	3	1	1	1	0	1	3	1	1
Penetration/aspiration (7)		0	2	0	0	0	0	0	0	4	5	0	3
Dysphagic severity		M	M-S	S	S	S	M	M	M	S	S	S	S

Dysphagic patient	No.	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24
	Age (yrs)	76	69	72	56	67	62	75	43	61	70	65	61
	Gender	M	M	F	M	M	M	M	M	M	F	M	M
Velar elevation (max: 3)		0	0	0	0	0	0	0	0	0	0	0	0
Hyo-laryngeal excursion (3)		2	0	0	0	1	0	0	1	2	0	0	1
Epiglottic inversion (3)		1	0	1	0	0	0	0	1	4	1	1	0
UES opening (2)		0	1	0	0	0	1	0	1	2	0	0	0
Pharyngeal peristalsis (2)		0	0	0	0	0	0	0	1	2	0	0	0
Vallecular residue (3)		1	1	1	1	0	1	0	1	4	1	1	0
Pyriform sinus residue (3)		0	1	1	0	0	0	0	1	2	1	1	0
Delayed swallow reflex (2)		2	0	2	1	1	0	1	0	2	0	1	1
Penetration/aspiration (7)		0	0	0	0	0	0	0	2	3	0	0	0
Dysphagic severity		S	S	M-S	M	M	M	M	M-S	S	M	M	M

Dysphagic patient	No.	P25	P26	P27	P28	P29	P30	P31	P32	P33	P34	P35	P36
	Age (yrs)	61	63	62	54	78	81	59	54	55	66	85	75
	Gender	M	M	F	M	F	M	M	M	M	M	F	M
Velar elevation (max: 3)		0	0	0	0	0	0	0	0	0	0	0	0
Hyo-laryngeal excursion (3)		0	0	2	0	0	2	1	0	0	2	1	0
Epiglottic inversion (3)		1	1	1	1	1	1	1	0	0	1	1	1
UES opening (2)		0	0	0	0	0	0	1	1	0	0	1	0
Pharyngeal peristalsis (2)		0	0	0	0	0	0	1	0	0	0	1	0
Vallecular residue (3)		1	2	1	1	1	1	1	1	0	1	1	2
Pyriform sinus residue (3)		1	2	0	1	0	0	1	1	0	0	1	2
Delayed swallow reflex (2)		1	2	2	0	1	2	0	0	1	2	0	2
Penetration/aspiration (7)		0	0	0	0	0	0	2	0	0	0	2	0
Dysphagic severity		M	S	S	M	M	S	S	M	M	M-S	S	S

Notes. Gender: M = male, F = female; Dysphagic severity: M = mild, M-S = mild to moderate/severe, S = moderate/severe

Meanwhile, more than moderate (moderate, moderate to severe, and severe) was combined as moderate/severe in the present study due to vagueness of dysphagic severity classification only by VFSS video evaluation and consideration for importance of discovering mild patients in terms of dysphagic treatment. As a statistical model for discriminating dysphagic severity, the cumulative *logit* model, one of logistic regression models, was applied to classify into more than three ordinal categories (Figure 8.3).

Five cumulative *logit* model candidates for swallowing dry saliva, thin liquid 1 ml, 3 ml, thick liquid 1 ml, and 3 ml were developed to select an optimal diagnostic model for dysphagia considering discriminant performance and practicality. Input variables by cumulative *logit* model were selected by applying stepwise regression technique ($p_{\text{in}} = p_{\text{out}} = 0.05$) given age, gender, and five swallowing quantification measures (highest peak amplitude, duration time, number of peaks, longest peak-to-peak interval, and impulse) as

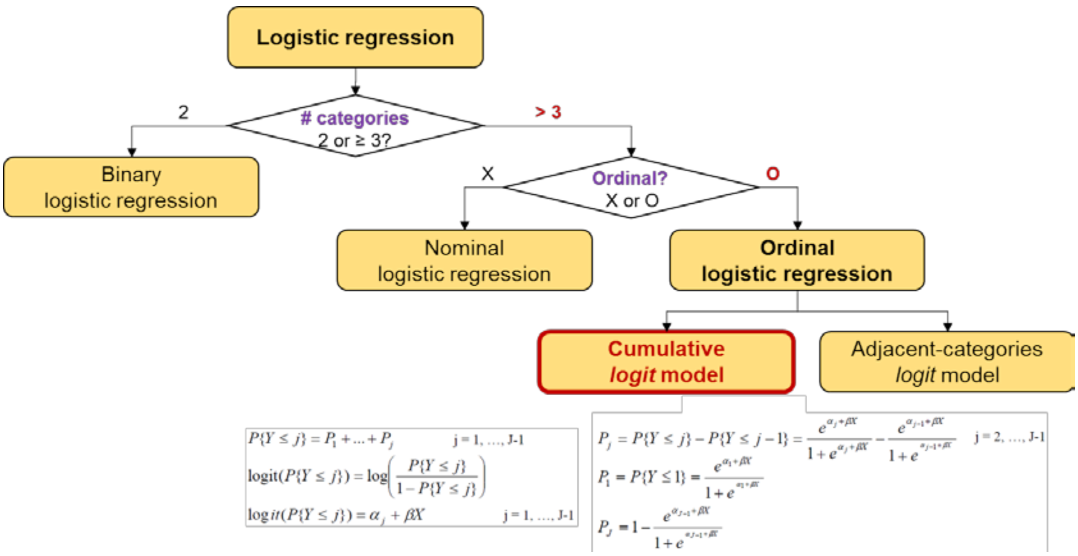


Figure 8.3. Logistic regression models for categorization

shown in Figure 8.4. Five cumulative *logit* models for swallowing dry saliva, thin liquid 1 ml, 3 ml, thick liquid 1 ml, and 3 ml were developed except for swallowing thin liquid 9 ml and thick liquid 9 ml not experimented by dysphagic patients in the present study. The cumulative *logit* model estimates the probability (P_1: normal, P_2: mild, and P_3: moderate/severe) of a dysphagic severity and discriminates a category with the highest probability as estimated category. For example, dysphagic severity of a patient with $P_1 = 0.3$, $P_2 = 0.5$, and $P_3 = 0.2$ is discriminated into mild.

Dysphagic severity was finally determined into the most dysphagic severity out of three experimented swallowing data and four discriminant performances (sensitivity for mild, sensitivity for moderate/severe, specificity, and accuracy) were compared among cumulative *logit* models. The present study adopted the most dysphagic severity out of

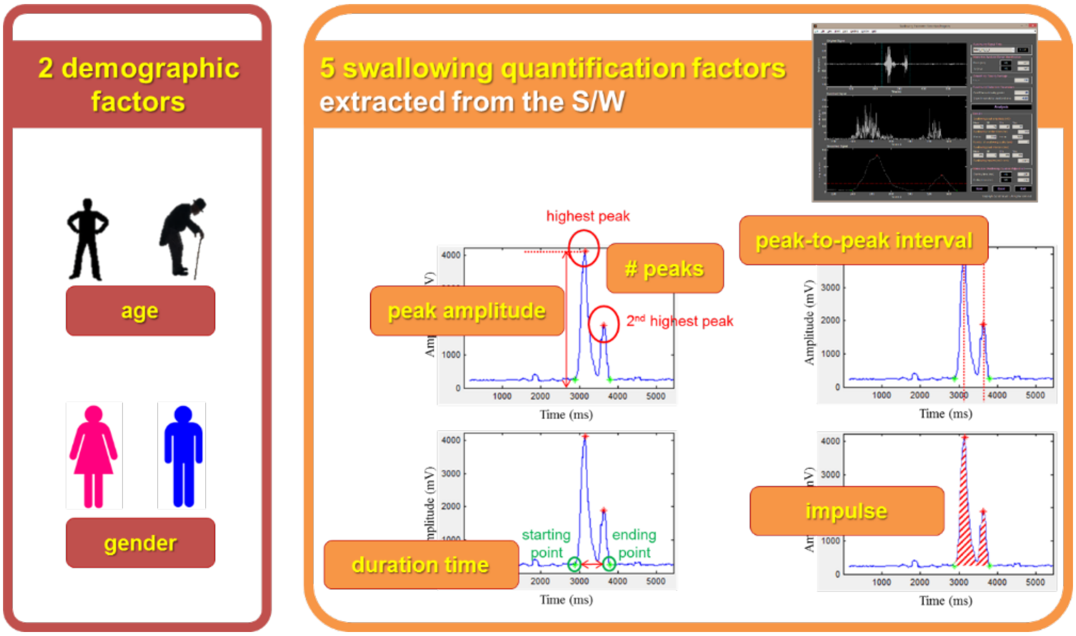


Figure 8.4. Candidates of input variables for applying discriminant models for dysphagia

three experimented swallowing data by swallowing liquid type and volume based on the swallowing feature that dysphagic severity of each swallowing can be different (Ekberg, 2012). Following shows examples of determining dysphagic severity: three normal swallowing → normal; two normal and one mild swallowing → mild; one normal, one mild, and one moderate/severe → moderate/severe. For comparison of discriminant performances among cumulative *logit* models, specificity (normal → normal), $\text{sensitivity}_{\text{mild}}$ (mild → mild), $\text{sensitivity}_{\text{moderate/severe}}$ (moderate/severe → moderate/severe), and accuracy (average of specificity, $\text{sensitivity}_{\text{mild}}$, and $\text{sensitivity}_{\text{moderate/severe}}$) were calculated.

Swallowing data of 120 healthy adults and 31 out of 36 dysphagic patients were used except for swallowing data of five dysphagic patients with missing data and diagnosed as mild to moderate/severe in the development of cumulative *logit* models for discriminating dysphagic severity. Swallowing data of four dysphagic patients (P02, P15, P20, and P34) diagnosed as mild to moderate/severe by VFSS video evaluation were excluded in the analysis due to vagueness of comparison with the estimated category (normal, mild, and moderate/severe) by the cumulative *logit* model. In addition, swallowing data of one mild patients (P10) having missing data for dry saliva, thin liquid 3 ml, and thick liquid 3 ml was excluded for considering discriminant accuracy.

8.2. Dysphagic Diagnostic Model

The cumulative *logit* model for thin liquid 1 ml (accuracy = 81%) was selected as optimal diagnostic model for dysphagia in terms of discriminant performance and practicality. Figure 8.5 shows five cumulative *logit* models for dry saliva, thin liquid 1 ml, 3 ml, thick liquid 1 ml, and 3 ml. For example, as shown in Figure 8.5a, the cumulative *logit* model for dry saliva estimates the probability (P_1: normal, P_2: mild, and P_3: moderate/severe) of a dysphagic severity given age, duration time, number of peaks, and impulse. Primary variables for dysphagic severity discrimination were age, duration time, and impulse commonly used in the five cumulative *logit* models. The present study proposes the cumulative *logit* model for thin liquid 1 ml as optimal diagnostic model for dysphagic severity discrimination due to its highest discriminant performances ($\text{sensitivity}_{\text{mild}}$ = 50%, $\text{sensitivity}_{\text{moderate/severe}}$ = 92%, specificity = 100%, accuracy = 81%) and relatively superior practicality (water + measurement spoon) compared with cumulative *logit* models for thick liquid (beverage 100 ml + thickener 4.5 g + measurement spoon). In terms of discrimination of discovering dysphagia, the optimal diagnostic model showed superior performances with the discrimination rate of 100% (120/120) for healthy adults and 94% (29/31) for dysphagic patients. In addition, to improve $\text{sensitivity}_{\text{mild}}$, the present study applied cost ratio of 0.21:0.66:0.13 = normal:mild:moderate/severe into the optimal diagnostic model. As a result as shown in Figure 8.7, the optimal diagnostic model applied with the cost ratio showed $\text{sensitivity}_{\text{mild}}$ = 83%, $\text{sensitivity}_{\text{moderate/severe}}$ = 62%, specificity = 91%, and accuracy = 79%.

The optimal diagnostic model misclassified nine mild patients into two normal and seven moderate/severe and one moderate/severe patient into mild. Two patients (P07 and

DS	Coef.	SE Coef.	z	p	Odds ratio	Lower 95% C.I.	Upper 95% C.I.
Constant(1)	7.31357	0.787678	9.28	< 0.001	-	-	-
Constant(2)	9.12466	0.870398	10.48	< 0.001	-	-	-
Age	-0.0551526	0.0113272	-4.87	< 0.001	0.95	0.93	0.97
Gender							
Highest peak amplitude							
Duration time	-0.0032898	0.0005168	-6.37	< 0.001	1.00	1.00	1.00
Number of peaks	-1.23836	0.247478	-5.00	< 0.001	0.29	0.18	0.47
Longest peak-to-peak interval							
Impulse	0.0004149	0.0001145	3.62	< 0.001	1.00	1.00	1.00

$$logit(P\{Y \le 1\}) = 7.31357 - 0.0551526 \times Age + \cdots + 0.0004149 \times Impulse$$

$$logit(P\{Y \le 2\}) = 9.12466 - 0.0551526 \times Age + \cdots + 0.0004149 \times Impulse$$

$$P_1 = \frac{e^{7.31357 - 0.0551526 \times Age + \cdots + 0.0004149 \times Impulse}}{1 + e^{7.31357 - 0.0551526 \times Age + \cdots + 0.0004149 \times Impulse}}$$

P_1: probability for normal

$$P_2 = \frac{e^{9.12466 - 0.0551526 \times Age + \cdots + 0.0004149 \times Impulse}}{1 + e^{9.12466 - 0.0551526 \times Age + \cdots + 0.0004149 \times Impulse}} - P_1$$

P_2: probability for mild

$$P_3 = 1 - P_1 - P_2$$

P_3: probability for moderate/severe

(a) Dry saliva

TN1	Coef.	SE Coef.	z	p	Odds ratio	Lower 95% C.I.	Upper 95% C.I.
Constant(1)	9.75737	1.48158	6.59	< 0.001	-	-	-
Constant(2)	12.6793	1.66442	7.62	< 0.001	-	-	-
Age	-0.0679622	0.0161091	-1.04	< 0.001	0.93	0.91	0.96
Gender	-0.473874	0.453826	-4.22	0.296	0.62	0.26	1.52
Highest peak amplitude							
Duration time	-0.0044315	0.0009985	-4.44	< 0.001	1.00	0.99	1.00
Number of peaks	-1.09820	0.299820	-3.66	< 0.001	0.33	0.19	0.60
Longest peak-to-peak interval	-0.0017712	0.0012461	-1.42	0.155	1.00	1.00	1.00
Impulse	0.0004320	0.0001135	3.81	< 0.001	1.00	1.00	1.00

$$logit(P\{Y \le 1\}) = 9.75737 - 0.0679622 \times Age + \cdots + 0.0004320 \times Impulse$$

$$logit(P\{Y \le 2\}) = 12.6793 - 0.0679622 \times Age + \cdots + 0.0004320 \times Impulse$$

$$P_1 = \frac{e^{9.75737 - 0.0679622 \times Age + \cdots + 0.0004320 \times Impulse}}{1 + e^{9.75737 - 0.0679622 \times Age + \cdots + 0.0004320 \times Impulse}}$$

P_1: probability for normal

$$P_2 = \frac{e^{12.6793 - 0.0679622 \times Age + \cdots + 0.0004320 \times Impulse}}{1 + e^{12.6793 - 0.0679622 \times Age + \cdots + 0.0004320 \times Impulse}} - P_1$$

P_2: probability for mild

$$P_3 = 1 - P_1 - P_2$$

P_3: probability for moderate/severe

(b) Thin liquid 1 ml

TN3	Coef.	SE Coef.	z	p	Odds ratio	Lower 95% C.I.	Upper 95% C.I.
Constant(1)	8.36336	1.25748	6.65	< 0.001	-	-	-
Constant(2)	11.4793	1.45489	7.89	< 0.001	-	-	-
Age	-0.0853626	0.0170547	-5.01	< 0.001	0.92	0.89	0.95
Gender							
Highest peak amplitude							
Duration time	-0.0038975	0.0008622	-4.52	< 0.001	1.00	0.99	1.00
Number of peaks							
Longest peak-to-peak interval	-0.0049418	0.0012008	-4.12	< 0.001	1.00	0.99	1.00
Impulse	0.0003317	0.0001124	2.95	0.003	1.00	1.00	1.00

$$logit(P\{Y \leq 1\}) = 8.36336 - 0.0853626 \times Age + \cdots + 0.0003317 \times Impulse$$

$$logit(P\{Y \leq 2\}) = 11.4793 - 0.0853626 \times Age + \cdots + 0.0003317 \times Impulse$$

$$P_1 = \frac{e^{8.36336-0.0853626\times Age+\cdots+0.0003317\times Impulse}}{1+e^{8.36336-0.0853626\times Age+\cdots+0.0003317\times Impulse}}$$

P_1: probability for normal

$$P_2 = \frac{e^{11.4793-0.0853626\times Age+\cdots+0.0003317\times Impulse}}{1+e^{11.4793-0.0853626\times Age+\cdots+0.0003317\times Impulse}} - P_1$$

P_2: probability for mild

$$P_3 = 1 - P_1 - P_2$$

P_3: probability for moderate/severe

(c) Thin liquid 3 ml

TK1	Coef.	SE Coef.	z	p	Odds ratio	Lower 95% C.I.	Upper 95% C.I.
Constant(1)	8.93108	1.13166	7.89	< 0.001	-	-	-
Constant(2)	11.7554	1.31716	8.92	< 0.001	-	-	-
Age	-0.0918191	0.0140684	-6.53	< 0.001	0.91	0.89	0.94
Gender							
Highest peak amplitude							
Duration time	-0.0031407	0.0007659	-4.10	< 0.001	1.00	1.00	1.00
Number of peaks	-0.870023	0.269081	-3.23	0.001	0.42	0.25	0.71
Longest peak-to-peak interval	-0.0026136	0.0010064	-2.60	0.009	1.00	1.00	1.00
Impulse	0.0004373	0.0001066	4.10	< 0.001	1.00	1.00	1.00

$$logit(P\{Y \leq 1\}) = 8.93108 - 0.0918191 \times Age + \cdots + 0.0004373 \times Impulse$$

$$logit(P\{Y \leq 2\}) = 11.7554 - 0.0918191 \times Age + \cdots + 0.0004373 \times Impulse$$

$$P_1 = \frac{e^{8.93108-0.0918191\times Age+\cdots+0.0004373\times Impulse}}{1+e^{8.93108-0.0918191\times Age+\cdots+0.0004373\times Impulse}}$$

P_1: probability for normal

$$P_2 = \frac{e^{11.7554-0.0918191\times Age+\cdots+0.0004373\times Impulse}}{1+e^{11.7554-0.0918191\times Age+\cdots+0.0004373\times Impulse}} - P_1$$

P_2: probability for mild

$$P_3 = 1 - P_1 - P_2$$

P_3: probability for moderate/severe

(d) Thick liquid 1 ml

TK3	Coef.	SE Coef.	z	p	Odds ratio	Lower 95% C.I.	Upper 95% C.I.
Constant(1)	9.40521	1.07319	8.76	< 0.001	-	-	-
Constant(2)	11.6416	1.19524	9.74	< 0.001	-	-	-
Age	-0.0765633	0.0142458	-5.37	< 0.001	0.93	0.90	0.95
Gender							
Highest peak amplitude	-0.0346978	0.0234104	-1.48	0.138	0.97	0.92	1.01
Duration time	-0.0040954	0.0006192	-6.61	< 0.001	1.00	0.99	1.00
Number of peaks	-1.15080	0.258852	-4.45	< 0.001	0.32	0.19	0.53
Longest peak-to-peak interval							
Impulse	0.0005575	0.0001576	3.54	< 0.001	1.00	1.00	1.00

$$logit(P\{Y \leq 1\}) = 9.40521 - 0.0765633 \times Age + \cdots + 0.0005575 \times Impulse$$

$$logit(P\{Y \leq 2\}) = 11.6416 - 0.0765633 \times Age + \cdots + 0.0005575 \times Impulse$$

$$P_1 = \frac{e^{9.40521 - 0.0765633 \times Age + \cdots + 0.0005575 \times Impulse}}{1 + e^{9.40521 - 0.0765633 \times Age + \cdots + 0.0005575 \times Impulse}}$$

P_1: probability for normal

$$P_2 = \frac{e^{11.6416 - 0.0765633 \times Age + \cdots + 0.0005575 \times Impulse}}{1 + e^{11.6416 - 0.0765633 \times Age + \cdots + 0.0005575 \times Impulse}} - P_1$$

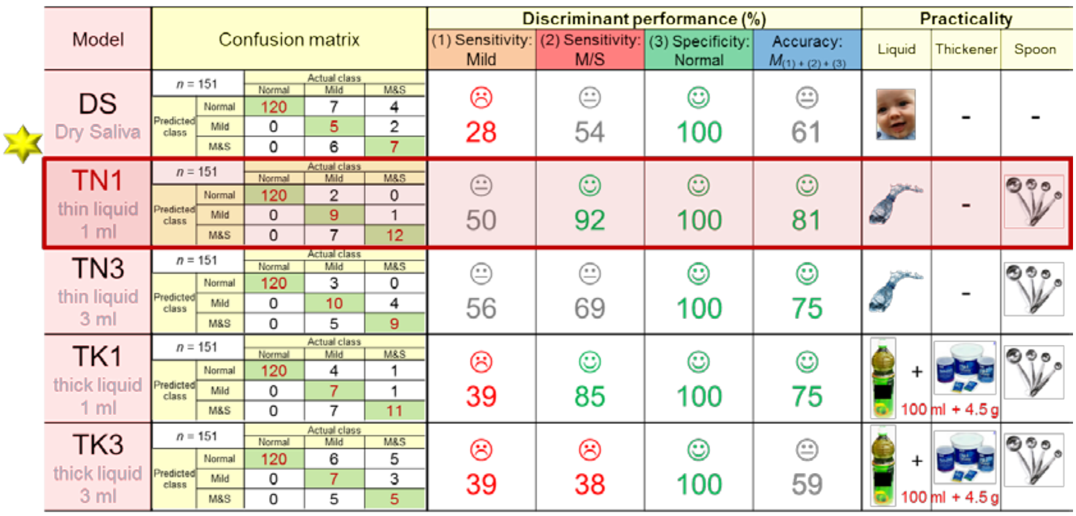
P_2: probability for mild

$$P_3 = 1 - P_1 - P_2$$

P_3: probability for moderate/severe

(e) Thick liquid 3 ml

Figure 8.5. Cumulative logit models for discriminating dysphagia severity



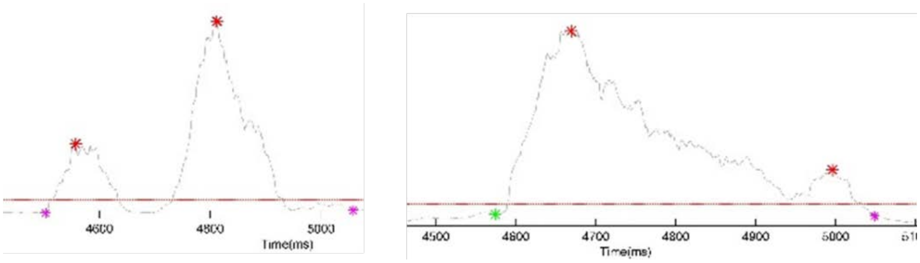
Model	Confusion matrix (n = 151; rows: Predicted class Normal / Mild / M&S; columns: Actual class Normal / Mild / M&S)	Discriminant performance (%): (1) Sensitivity: Mild	(2) Sensitivity: M/S	(3) Specificity: Normal	Accuracy: $M_{(1)+(2)+(3)}$	Practicality: Liquid	Thickener	Spoon
DS Dry Saliva	Normal: 120, 7, 4 Mild: 0, 5, 2 M&S: 0, 6, 7	28	54	100	61		-	-
TN1 thin liquid 1 ml	Normal: 120, 2, 0 Mild: 0, 9, 1 M&S: 0, 7, 12	50	92	100	81		-	
TN3 thin liquid 3 ml	Normal: 120, 3, 0 Mild: 0, 10, 4 M&S: 0, 5, 9	56	69	100	75		-	
TK1 thick liquid 1 ml	Normal: 120, 4, 1 Mild: 0, 7, 1 M&S: 0, 7, 11	39	85	100	75	100 ml + 4.5 g		
TK3 thick liquid 3 ml	Normal: 120, 6, 5 Mild: 0, 7, 3 M&S: 0, 5, 5	39	38	100	59	100 ml + 4.5 g		

Figure 8.6. Comparison of discriminant performances and practicality among cumulative logit models for discriminating dysphagia severity

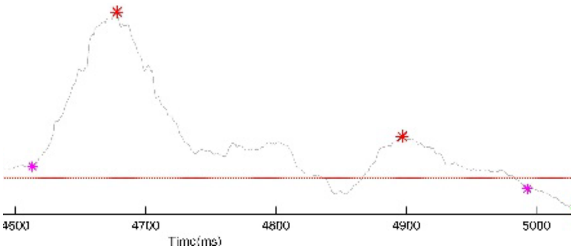
P08) were evaluated as mild by VFSS video evaluation, but were classified as normal by the optimal diagnostic model due to their similar laryngopharyngeal movement signal pattern with normal signal patterns as shown in Figure 8.7. Eight dysphagic patients were classified into different severity category (seven patients: mild → moderate/severe; one patient: moderate/severe → mild). The aforementioned result is attributable to that pharyngeal dysfunction evaluation results having relative small relationship with the laryngopharyngeal movement such as delayed swallow reflex would affect more to the dysphagic severity evaluation.

Model	Confusion matrix				Discriminant performance (%)			
		Actual class			(1) Sensitivity: Mild	(2) Sensitivity: M/S	(3) Specificity: Normal	Accuracy: $M_{(1)+(2)+(3)}$
	Predicted class	Normal	Mild	M&S				
TN1	Normal	120	2	0	😐 50	☺ 92	☺ 100	☺ 81
	Mild	0	9	1				
	M&S	0	7	12				
TN1 applied cost ratio normal:mild:moderate/severe = 0.21:0.66:0.13	Normal	109	1	0	☺ 83	😐 62	☺ 91	☺ 79
	Mild	11	15	5				
	M&S	0	2	8				

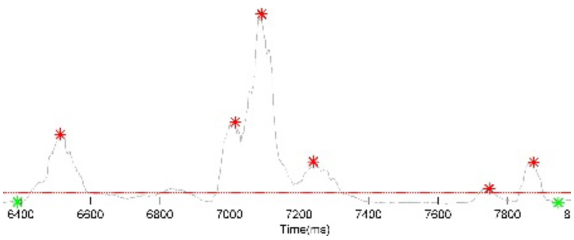
Figure 8.7. Comparison of discriminant performances of cumulative logit models between before and after applying cost ratio for improvement of sensitivity for mild



(a) Misclassified cases (left: P07, right: P08)



(b) Normal case



(c) Dysphagic case

Figure 8.8. Comparison of ultrasonic Doppler signal among misclassified cases (mild → normal), a normal case, and a dysphagic case

Chapter 9 DISCUSSION

The present study quantified the human swallow by measuring ascending and descending movements of the laryngopharynx during swallowing. The precedent study (Lee, Jung, et al., 2012) developed the swallowing measurement device (SMD) which converts movements of the laryngopharynx into a swallowing signal using the ultrasonic Doppler sensor. The present study developed the signal processing technique, which applied the signal rectification and smoothing algorithm, specialized in reducing noises and clarifying peaks of the swallowing signal measured by the SMD and then established the five swallowing quantification measures (peak amplitude, duration time, number of peaks, peak-to-peak interval, and impulse) defined using the starting point, peak, and ending point extracted from the smoothed swallowing signal. The effectiveness of the swallowing quantification measures was examined by understanding their meanings (peak amplitude: maximum instant movement of the laryngopharynx, duration time: total movement time in the laryngopharynx, number of peaks: number of movement types in the laryngopharynx, peak-to-peak interval: bolus transportation time in the pharyngeal stage, and impulse: total movement of the laryngopharynx) through interoperation of the swallowing signal with the corresponding VFSS video. In clinics, swallowing functions have been mainly diagnosed by conducting videofluorocopic swallowing study (VFSS) and/or fiberoptic endoscopic evaluation of swallowing (FEES), but these clinical methods rely on a medical opinion, not quantitative measurements, provided by clinicians. Therefore, the quantitative assessment methodology of the pharyngeal swallow, which quantifies the movement of the laryngopharynx during swallowing, developed in the present study can contribute to evaluating the human swallow with high accuracy.

The swallowing screening algorithm, which only discriminates the swallowing activity out of up-and-down pharyngeal movement-related activities measured by the ultrasonic Doppler sensor, was developed and validated for real-time and accurate evaluation of swallowing. Found that the ultrasonic Doppler sensor, attached on the neck surface, of the SMD detected not only swallowing but also vocalization, coughing, respiration, and neck motions such as rotation and flexion/extension. To distinguish swallowing from various up-and-down pharyngeal movement-related activities in daily life, a unique swallowing characteristic which respiration and vocalization are impossible due to the closure of the vocal folds during the pharyngeal stage of swallowing was applied to development of the swallowing screening algorithm. Accordingly, the present study employed a miniature microphone into the SMD for measuring synchronized audio signal with movement signal occurred in the pharynx. The movement-to-audio signal invented in the present study discriminated 100% swallowing, having high movement but low audio values, from vocalization and coughing, having high movement and audio values, which had similar patterns with the swallowing signal. Meanwhile, respiration and neck motions, which had different patterns with the swallowing signal, were screened only using movement signal by applying the moving average technique. Therefore, the swallowing screening algorithm developed in the present study can be applicable to accurate and real-time selection of swallowing out of various pharyngeal movement-related activities measured by the ultrasonic Doppler sensor.

In the oral stage, before the pharyngeal stage, out of the normal swallow phase, 20% of healthy adults showed the ascending movement of the laryngopharynx located in the pharyngeal during swallowing. The present study found that two peaks on the swallowing signal occurred when ascending (high peak) and descending (low peak) movements of the laryngopharynx during swallowing were apparently separated and one peak when those time difference was relatively short, by observation of VFSS and neck surface videos recorded when swallowing water 1 ml. The relative frequency of which number of peaks = 1, 2, and more than 3 on the swallowing signal was found 43%, 39%, and 18%, respectively. By VFSS analysis when occurring three peaks, the 1st peak was found occurred in the oral stage, before that pharyngeal stage, when moving the laryngopharynx due to the elevation of the soft palate, while the 2nd and 3rd peaks were found occurred in the pharyngeal stage when moving the laryngopharynx upward and downward, respectively. Estimated that the aforementioned human swallow strategy occurring the laryngopharynx movement in the oral stage would be one of the pre-pharyngeal shortening activities for more precise and safety swallow.

By the identification of the representative swallowing type, the present study found that movement time of the laryngopharynx was less than 1 s in all healthy adults, but that was more than 1 s in 80% of dysphagic patients. The present study identified the three healthy swallowing types (short-double peak, short-single peak, short-multiple peak) and the three dysphagic swallowing types (short-double peak, long-double peak, long-multiple peak) by clustering analysis using the three swallowing quantification measures (peak amplitude, duration time, and number of peaks) and then determined the representative swallowing type in each identified swallowing type. The representative short-double peak type, which includes two peaks and duration time < 1 s, was identified in common with healthy adults (395 ms, 43%) and dysphagic patients (465 ms, 19%), but the other representative swallowing types (short-single peak: 199 ms, 39%; short-multiple peak: 662 ms, 18%) of healthy adults showed duration time < 1 s and those (long-double peak: 1,041 ms, 65%; long-multiple peak: 1,463 ms, 16%) of dysphagic patients showed duration time > 1 s. The representative swallowing type of healthy adults and dysphagic patients identified in the present study can be used as a swallowing classification guideline for quantifying swallowing characteristics by using the SMD.

The present study found that the movement of the laryngopharynx of healthy adults was increased in swallowing food with a low viscosity and a high volume. The effects of swallowing food type and volume were found commonly significant on peak amplitude and impulse, which are related to the degree of the laryngopharynx movement. Healthy adults showed 24% bigger and 36% more movements of the laryngopharynx in swallowing thin liquid having high viscosity relatively than swallowing thick liquid having low viscosity. The aforementioned result can be utilized as a basis that most dysphagic patients tend to mix food with thickeners such as Thick&Easy (Hormel Health Labs, USA) to increase viscosity for easy and smoothing swallowing. Meanwhile, healthy adults showed 30% bigger and 37% more movements of the laryngopharynx in swallowing 9 ml relatively than swallowing 1 ml. The aforementioned result agrees on the swallowing reflex process which swallowing-related organs are moved proportional to the swallowing volume calculated by the cerebral hemisphere when the bolus is passed inside the tongue (Miller, 1999; Perlman & Christensen, 1997).

The present study revealed quantitatively that dysphagic patients showed 1/3 times lower and 2.6 times longer movements of the laryngopharynx during swallowing compared to healthy adults. The present study quantified the swallowing capability of healthy adults and dysphagic patients in terms of dry saliva, thick liquid 1 ml, thick liquid 3 ml, thin liquid 1 ml, and thick liquid 3 ml, and then found that dysphagic patients showed lower swallowing performances in all swallowing conditions, regardless of the swallowing volume, than healthy adults. The aforementioned result indicates that the swallowing signal of dysphagic patients is distinguished with that of healthy adults, and then the evaluation of the swallowing signal can be used for screening dysphagia. Thus, the swallowing characteristic of healthy adults and dysphagic patients revealed in the present study can be used as a guideline for a diagnosis with dysphagia when acquiring the swallowing signal during swallowing.

The diagnostic model for dysphagia developed in the present study can evaluate the severity of dysphagic patients as normal, mild, moderate/severe. The present study found that diagnostic models for dysphagia/swallowing did not exist based on comprehensive literature review. The diagnostic model for dysphagia evaluates the severity of dysphagia using real-time data measured by the ultrasonic Doppler when swallowing saliva or a small quantity of water (e.g., 1 ml) considering practicality in clinics. The cumulative *logit* model of ordinal logistic regression was applied in the diagnostic model for dysphagia for discriminating not only the existence of dysphagia but also the severity of dysphagia such as normal, mild, and moderate/severe levels. The diagnostic model for dysphagia showed sensitivity for mild = 50%, sensitivity for moderate/severe = 92%, specificity = 100%, and accuracy = 81%. The swallowing activity can be quantitatively categorized in real time when employing the diagnostic model for dysphagia into the SMD. Thus, the diagnostic model for dysphagia can contribute to enhancing accuracy and efficiency of dysphagia evaluation.

A mobile swallowing monitoring and assessment system (mobile-SMAS) being employing the quantitative assessment methodology of pharyngeal swallow proposed in the present study can contribute to monitoring, quantitative assessment, biofeedback of swallowing based on real-time measurement. The mobile-SMAS would be the first of its kind in the world which provides real-time functions of quantitative swallowing assessment and can be used at hospitals, community healthcare centers, nursing facilities, and homes to provide better clinical services for patients with dysphagia. Compared with the conventional dysphagia examination methods such as VFSS and FEES, which highly rely on observations and subjective evaluations of the examiner, the mobile SMAS has distinguished features such as better safety, comfort, objectivity, accessibility, portability, and competitive price. Furthermore, the ICT technology based SMAS can provide various smart functions such as biofeedback and quantitative analysis on swallowing activities in daily life, which can extend its usage to other applications such as assist devices of diet management and rehabilitation for patients with Parkinson’s disease.

Chapter 10 CONCLUSION

The present study was to achieve five objectives for swallowing quantification as following: (1) discrimination of swallowing from other pharyngeal activities occurred in the signal measured by the ultrasonic Doppler, (2) quantification of the swallowing signal, (3) interpretation of the swallowing signal by interoperating with the laryngopharynx motion during swallowing, (4) comparison of swallowing characteristics between healthy people and patients with dysphagia, and (5) development of a diagnostic model for dysphagia.

First, the present study developed the swallowing screening algorithm for discriminating the swallowing activity from various laryngopharynx movement-related activities such as vocalization, coughing, respiration, and neck motions measured by the ultrasonic Doppler. The swallowing screening algorithm including smoothing and filtering techniques was developed based on the laryngopharyngeal protective mechanism which respiration and vocalization are impossible due to the closure of the vocal folds during the pharyngeal stage of swallowing. The movement-to-audio signal proposed in the present study discriminated swallowing 100% from vocalization, coughing, respiration, and neck motions.

Second, the present study developed the signal processing technique for the swallowing signal and established swallowing measures to quantify the swallowing activity. The quantification protocol of swallowing was developed to identify characteristics of swallowing by using the swallowing signal measured by ultrasonic

Doppler during swallowing. Swallowing measures (e.g., swallowing duration) were extracted from the swallowing signal by development of the swallowing automatic quantification program.

Third, the present study interpreted the swallowing signal by interoperating with VFSS video recorded during swallowing. Meanings by reference point such as starting/ending points and peak on the swallowing signal were apprehended through real-time synchronization of the VFSS video and the swallowing signal measured during swallowing. The swallowing measures were interpreted based on the meaning of the swallowing signal with experts of dysphagia.

Forth, the present study compared patients with dysphagia with healthy people in terms of the swallowing measures by conducting the swallowing experiment. The swallowing experiment was conducted for participants to swallow saliva, thin liquid 1, 3, 9 ml, and thick liquid 1, 3, 9 ml. The effects of age, gender, swallowing food, and swallowing volume on the swallowing measure were examined. Swallowing characteristics of patients with dysphagia were compared to those of healthy people.

Lastly, the present study developed the optimal diagnostic model for dysphagia to classify a dysphagia severity level as normal, mild, and moderate/severe. Input variables of the diagnostic model were selected as age, highest peak amplitude, duration time, number of peaks, and impulse which were significant on the severity of dysphagia. The optimal diagnostic model for dysphagia was developed by applying the ordinal logistic regression and used the swallowing signal for water 1 ml considering practicality and performance.

The diagnostic model for dysphagia showed sensitivity for mild = 50%, sensitivity for moderate/severe = 92%, specificity = 100%, and accuracy = 81%.

The mobile swallowing monitoring and assessment system (mobile-SMAS) employing the quantitative assessment methodology of the pharyngeal swallow developed in the present study would contribute to monitoring, quantitative assessment, biofeedback of swallowing based on real-time measurement. The mobile-SMAS would be the first of its kind in the world which provides real-time functions of quantitative swallowing assessment and can be used at hospitals, community healthcare centers, nursing facilities, and homes to provide better clinical services for patients with dysphagia. Compared with the conventional dysphasia examination methods such as VFSS and FEES, which highly rely on observations and subjective evaluations of the examiner, the mobile-SMAS has distinguished features such as better safety, comfort, objectivity, accessibility, portability, and competitive price. Furthermore, the ICT technology based SMAS can provide various smart functions such as biofeedback and quantitative analysis on swallowing activities in daily life, which can extend its usage to other applications such as assist devices of diet management and rehabilitation for patients with Parkinson’s disease.

SUMMARY IN KOREAN

삼킴 장애(연하 곤란, dysphagia)는 음식을 먹는 과정에서 발생하는 어려움의 질병으로서 주로 신경계통 질병 환자와 65 세 이상 노년층에서 유병률이 높다. 삼킴 장애는 주로 흡인(aspiration), 폐렴(pneumonia), 탈수(dehydration), 영양실조(malnutrition) 등을 유발하고 심해지면 사망에 이를 수 있어 정확하고 신속한 진단이 중요하다. 기존 삼킴 장애는 주로 비디오 투시 조영 검사(videofluorocopic swallowing study, VFSS)와 비디오 내시경 검사(fiberoptic endoscopic evaluation of swallowing, FEES)를 통하여 진단되고 있으나 낮은 안전성(VFSS: 방사능, FEES: 침습)과 육안 평가의 한계가 있다. 선행 연구(Lee et al., 2012)에서는 삼킴 측정에 특화된 장비로서 인체에 무해한 ultrasonic Doppler 를 사용하여 삼킴 시 인두(pharynx)의 움직임을 측정하는 장비가 개발되었는데, 측정된 인두 삼킴(pharyngeal swallow) 신호 중 삼킴 움직임만을 선별, 정량화, 분석, 해석하고 삼킴 장애 진단에 특화 시키는 연구가 필요하다.

본 연구는 ultrasonic Doppler 를 사용하여 측정되는 인두 삼킴 신호를 사용하여 삼킴을 정량적으로 평가하기 위하여 (1) 인두 움직임 신호 중 삼킴 선별, (2) 삼킴 정량화 protocol 정립, (3) 삼킴 신호와 인두 움직임의 연동 해석, (4) 정상인과 삼킴 장애 환자의 삼킴 특성 비교 분석, 그리고 (5) 삼킴 장애 판별 모형 개발의 다섯 가지 세부 연구를 수행하였다.

첫째, ultrasonic Doppler 로 측정되는 다양한 인두 움직임 중 삼킴 움직임만이 선별하는 알고리즘이 개발되었다. 인두 삼킴 시 소리가 발생할 수 없는 삼킴 무호흡(swallowing apnea) 개념을 적용하기 위하여 ultrasonic Doppler sensor 에 소리 신호 획득을 위한 microphone 이 연동되었다. 인두 삼킴 시 인두 움직임이 발생하지만 소리 발생이 불가능한 개념 구현에 특화된 신호 처리(예: moving average)와 통계 기법(예: maximum-likelihood function)을 적용하여 삼킴

선별 알고리즘이 개발되었다. 효용성 평가 결과, 삼킴 선별 알고리즘은 삼킴과 기침 및 발성 같이 소리가 함께 발생하는 인두 움직임을 100% 구별하였다.

둘째, 삼킴 신호 분석에 특화된 신호 처리 기법이 개발되고 삼킴 정량화 척도가 정립되었다. 네 단계 삼킴 신호 처리 기법(S1. rectification, S2. smoothing, S3. peak detection, S4. starting/ending points detection)을 적용하여 삼킴 움직임 특성을 나타내는 다섯 가지 삼킴 정량화 척도(peak amplitude, duration time, number of peaks, peak-to-peak interval, 그리고 impulse)가 개발되었다. 삼킴 신호만 입력되면 삼킴 정량화 척도가 자동으로 추출되는 S/W 도 개발되었다.

셋째, 삼킴 시 삼킴 신호와 VFSS 영상을 동시에 획득하여 삼킴 신호와 인두 움직임이 연동 해석되었다. 정상 삼킴 신호의 peak 개수는 대부분 2 가지로 나타나며, 첫 번째 peak 는 삼킴 시 인후두(laryngopharynx) 상승 움직임을 두 번째 peak 는 삼킴 시 laryngopharynx 하강 움직임으로 파악되었다. VFSS 영상 분석 결과에 근간하여 peak amplitude 는 laryngopharynx 의 순간 최대 움직임 정도, duration time 은 laryngopharynx 의 총 움직임 시간, number of peaks 는 laryngopharynx 의 움직임 변환 횟수, peak-to-peak interval 는 인두 삼킴 시 bolus 이동 시간, 그리고 impulse 는 laryngopharynx 의 총 움직임 정도로 의미가 정립되었다.

넷째, 정상인과 삼킴 장애 환자를 대상으로 삼킴 실험을 수행하여 삼킴 특성이 비교 분석되었다. 정상인 120 명과 삼킴 장애 환자 36 명에 대해 침, thin liquid 1, 3, 9 ml, thick liquid 1, 3, 9 ml 삼킴에 대한 삼킴 신호가 획득되었다. 정상인의 number of peaks 는 1 개(49%) 또는 2 개(39%)일 때가 88%로 나타났다. 삼킴 정량화 척도에 대해 K-mean clustering 을 적용($K = 3$)한 별과, 정상인은 short-double peak (duration < 1 s and # peaks = 2)가 43%, short-single peak (duration < 1 s and # peaks = 1)가 39%, short-multiple peak (duration < 1 s and # peaks ≥ 3)가 18%로 나타났으며, 삼킴 장애 환자는 short-double peak (duration < 1 s and # peaks = 2)가 58%, long-double peak (duration ≥ 1 s and # peaks = 2)가 33%, long-multiple peak (duration ≥ 1 s and # peaks ≥ 3)가 9%인 것으로 나타났다. 정상인의 highest peak amplitude 에는 성별(female:male = 1:0.8), 삼킴 종류(thick liquid:thin liquid = 1:1.2), 삼킴 용량(1 ml:3 ml:9 ml = 1:1.1:1.3)이 유의하였으며, impulse 에는 삼킴 종류(thick liquid:thin liquid = 1:1.4)와 삼킴 용량(1 ml:3 ml:9 ml = 1:1.1:1.3)이 유의한 것으로 나타났다. 삼킴 장애 환자는 정상인에 비해 평균적으로 peak amplitude 가 0.7 배 낮고, duration time 이 2.6 배 길고, number of peaks 가 1.7 배 많고, peak-to-peak interval 이 4.3 배 길고, 그리고 impulse 가 0.8 배 낮은 것으로 나타났다.

마지막으로, 삼킴 장애 심각도를 normal, mild, 그리고 moderate/severe 로 분류하는 삼킴 장애 판별 모형이 개발되었다. 정상인 120 명과 삼킴 장애 환자 31 명(VFSS 진단 결과: mild 18 명, moderate/severe: 13 명)의 침, thin liquid 1 ml, 3 ml, thick liquid 1 ml, 그리고 3 ml 삼킴에 대한 5 가지 cumulative *logit* model 이 개발되었다. 최적 모형은 판별 성능과 실용성이 우수한 thin liquid 1 ml 삼킴에 대한 cumulative *logit* model (입력 변수: 연령, 성별, duration time, number of peaks, longest peak-to-peak interval, impulse; 판별 성능: sensitivity for mild = 50%, sensitivity for moderate/severe = 92%, specificity = 100%, accuracy = 81%)로 선정되었다.

본 연구의 ultrasonic Doppler 를 사용한 삼킴 시 laryngopharynx 움직임 정량화 방법론은 인두 삼킴을 실시간 정확하고 효과적으로 평가하는데 기여할 수 있다. 본 연구의 정상인과 삼킴 장애 환자의 삼킴 시 laryngopharynx 움직임 특성 비교 분석 결과와 삼킴 장애 심각도 판별 모형은 임상에서의 VFSS 검사와 더불어 삼킴 장애의 과학적 진단에 적용될 수 있을 것으로 기대된다.

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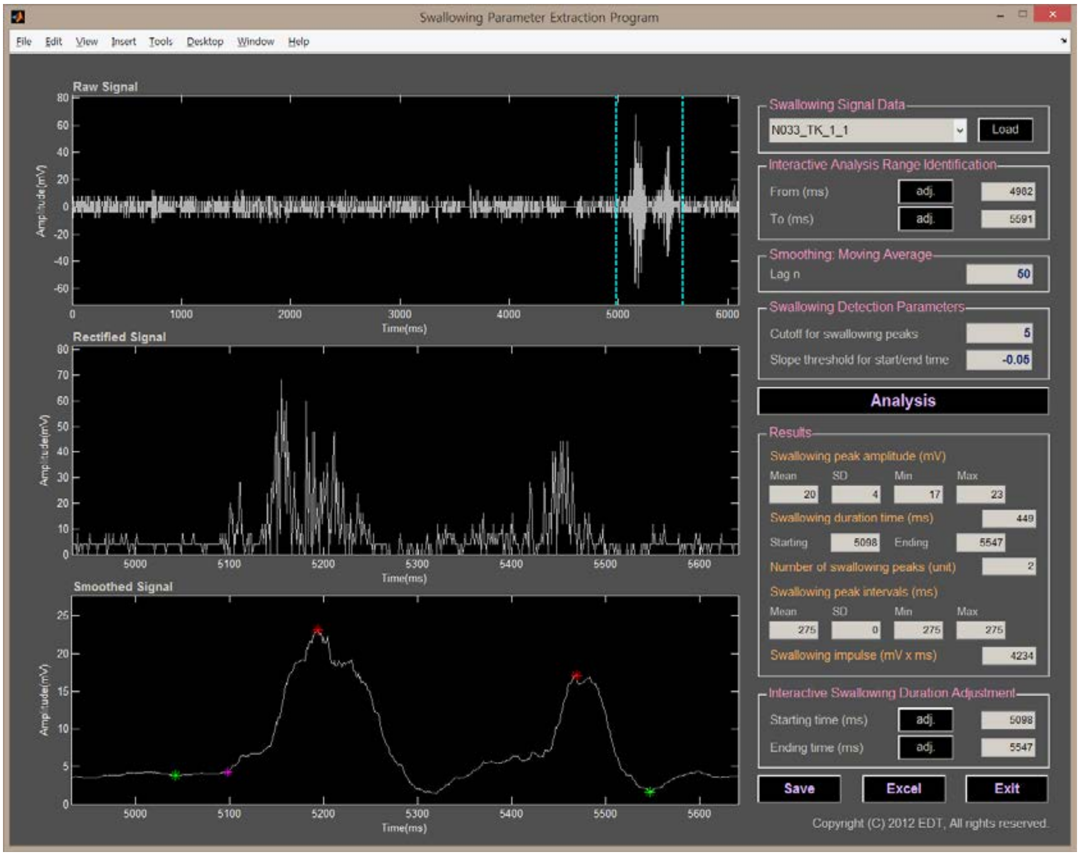
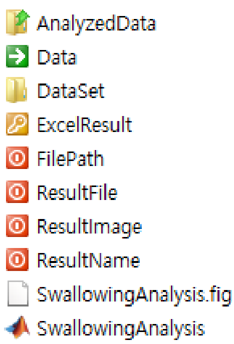
Appendix B. Swallowing Quantification Program

B.1. Layout of the swallowing quantification program



B.2. Structure of folders of the swallowing quantification program



Appendix D. Swallowing Data

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	1	F	20	DS	0	1	16.6	529	4	130	4862
HA	1	F	20	DS	0	2	33.0	351	1		4704
HA	1	F	20	DS	0	3	11.8	500	3	206	2763
HA	1	F	20	TK	1	1	14.8	423	2	252	3223
HA	1	F	20	TK	1	2	16.3	407	2	259	3069
HA	1	F	20	TK	1	3	8.5	450	2	243	2131
HA	1	F	20	TK	3	1	18.2	445	2	257	3547
HA	1	F	20	TK	3	2	12.6	481	1		2989
HA	1	F	20	TK	3	3	12.1	356	2	248	2404
HA	1	F	20	TK	9	1	18.1	484	2	287	3355
HA	1	F	20	TK	9	2	37.7	274	1		3906
HA	1	F	20	TK	9	3	28.6	293	1		3288
HA	1	F	20	TN	1	1	32.9	185	1		2512
HA	1	F	20	TN	1	2	19.5	244	1		2300
HA	1	F	20	TN	1	3	13.4	186	1		1428
HA	1	F	20	TN	3	1	26.2	341	1		3978
HA	1	F	20	TN	3	2	37.9	462	2	305	5379
HA	1	F	20	TN	3	3	20.9	422	1		3841
HA	1	F	20	TN	9	1	41.6	151	1		3332
HA	1	F	20	TN	9	2	86.8	410	1		9941
HA	1	F	20	TN	9	3	62.8	485	2	251	7621
HA	2	M	30	DS	0	1	20.1	805	2	646	5845
HA	2	M	30	DS	0	2	22.2	801	2	659	6707
HA	2	M	30	DS	0	3	22.0	587	2	407	4599
HA	2	M	30	TK	1	1	28.3	971	2	627	8045
HA	2	M	30	TK	1	2	42.7	819	3	339	8181
HA	2	M	30	TK	1	3	26.6	819	3	371	7361
HA	2	M	30	TK	3	1	23.6	719	3	359	5960
HA	2	M	30	TK	3	2	43.0	970	3	383	9024
HA	2	M	30	TK	3	3	34.8	769	3	352	7128
HA	2	M	30	TK	9	1	34.8	1064	4	454	9121
HA	2	M	30	TK	9	2	18.6	1073	2	593	9309
HA	2	M	30	TK	9	3	45.5	689	2	426	8356
HA	2	M	30	TN	1	1	38.7	184	1		3317
HA	2	M	30	TN	1	2	66.6	239	1		5571
HA	2	M	30	TN	1	3	45.0	222	1		4538
HA	2	M	30	TN	3	1	61.2	767	2	562	8959
HA	2	M	30	TN	3	2	25.4	792	2	476	7814
HA	2	M	30	TN	3	3	30.5	823	2	606	8025
HA	2	M	30	TN	9	1	72.4	894	2	539	14975
HA	2	M	30	TN	9	2	46.8	792	3	462	12420
HA	2	M	30	TN	9	3	67.4	773	2	480	13032
HA	3	F	50	DS	0	1	15.9	248	2	147	2630
HA	3	F	50	DS	0	2	11.2	367	1		2748
HA	3	F	50	DS	0	3	13.1	194	1		1690
HA	3	F	50	TK	1	1	21.9	428	2	239	3507
HA	3	F	50	TK	1	2	15.1	372	1		3663
HA	3	F	50	TK	1	3	17.4	267	1		2489
HA	3	F	50	TK	3	1	45.4	250	1		4110
HA	3	F	50	TK	3	2	26.4	400	1		4507
HA	3	F	50	TK	3	3	25.1	305	1		4082
HA	3	F	50	TK	9	1	34.2	254	1		4045
HA	3	F	50	TK	9	2	34.7	539	1		6331
HA	3	F	50	TK	9	3	30.2	558	1		6035
HA	3	F	50	TN	1	1	18.2	426	1		4805
HA	3	F	50	TN	1	2	15.0	647	3	183	5342
HA	3	F	50	TN	1	3	30.2	466	1		5716
HA	3	F	50	TN	3	1	37.5	341	1		4947
HA	3	F	50	TN	3	2	16.6	362	1		4027
HA	3	F	50	TN	3	3	19.0	504	1		5252
HA	3	F	50	TN	9	1	33.2	533	1		6859
HA	3	F	50	TN	9	2	62.7	561	1		10052
HA	3	F	50	TN	9	3	47.4	597	2	147	9019
HA	4	M	20	DS	0	1	24.6	529	2	424	4821
HA	4	M	20	DS	0	2	30.9	739	2	595	5743
HA	4	M	20	DS	0	3	25.5	677	2	512	5612
HA	4	M	20	TK	1	1	33.8	680	3	241	7761
HA	4	M	20	TK	1	2	47.5	760	2	579	7767
HA	4	M	20	TK	1	3	69.1	771	2	466	8480
HA	4	M	20	TK	3	1	28.8	571	2	439	4806
HA	4	M	20	TK	3	2	29.0	692	2	439	6053
HA	4	M	20	TK	3	3	48.7	808	2	472	7886
HA	4	M	20	TK	9	1	34.4	755	2	479	7843
HA	4	M	20	TK	9	2	41.4	731	2	472	8417
HA	4	M	20	TK	9	3	42.8	703	2	478	8883
HA	4	M	20	TN	1	1	20.2	826	2	438	6411
HA	4	M	20	TN	1	2	30.9	772	2	460	7519
HA	4	M	20	TN	1	3	30.2	692	2	456	7465
HA	4	M	20	TN	3	1	38.6	708	2	422	9022
HA	4	M	20	TN	3	2	45.8	797	2	446	8090
HA	4	M	20	TN	3	3	52.0	715	2	477	8295
HA	4	M	20	TN	9	1	89.6	667	2	448	11224
HA	4	M	20	TN	9	2	110.9	736	2	457	15248
HA	4	M	20	TN	9	3	86.6	720	2	461	12836
HA	5	M	20	DS	0	1	13.9	296	1		1607
HA	5	M	20	DS	0	2	8.0	157	1		626
HA	5	M	20	DS	0	3	24.3	221	1		1629
HA	5	M	20	TK	1	1	25.8	314	1		2770
HA	5	M	20	TK	1	2	54.6	394	2	211	6023
HA	5	M	20	TK	1	3	12.9	408	2	236	1793
HA	5	M	20	TK	3	1	32.8	433	2	250	4372
HA	5	M	20	TK	3	2	42.4	405	2	228	4460
HA	5	M	20	TK	3	3	22.6	360	2	248	2335
HA	5	M	20	TK	9	1	67.9	551	3	201	8235
HA	5	M	20	TK	9	2	88.6	402	1		12997
HA	5	M	20	TK	9	3	73.9	332	1		7474
HA	5	M	20	TN	1	1	32.1	386	2	127	4461
HA	5	M	20	TN	1	2	49.5	553	1		8877
HA	5	M	20	TN	1	3	34.4	495	1		7188
HA	5	M	20	TN	3	1	42.2	334	1		5678
HA	5	M	20	TN	3	2	27.0	488	1		6488
HA	5	M	20	TN	3	3	63.0	555	2	159	9419
HA	5	M	20	TN	9	1	48.4	395	1		7620
HA	5	M	20	TN	9	2	44.6	634	3	236	8922
HA	5	M	20	TN	9	3	27.8	435	1		4158

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	6	M	20	DS	0	1	22.2	243	1		2125
HA	6	M	20	DS	0	2	23.1	248	1		2127
HA	6	M	20	DS	0	3	13.2	162	1		1192
HA	6	M	20	TK	1	1	12.2	353	2	118	2143
HA	6	M	20	TK	1	2	24.0	507	2	115	4835
HA	6	M	20	TK	1	3	28.6	402	1		4266
HA	6	M	20	TK	3	1	45.7	431	1		6037
HA	6	M	20	TK	3	2	19.3	381	1		2080
HA	6	M	20	TK	3	3	37.5	439	2	134	5973
HA	6	M	20	TK	9	1	33.6	567	2	90	5320
HA	6	M	20	TK	9	2	28.5	356	1		5301
HA	6	M	20	TK	9	3	31.8	543	2	166	6867
HA	6	M	20	TN	1	1	34.6	297	1		3697
HA	6	M	20	TN	1	2	63.7	457	1		6499
HA	6	M	20	TN	1	3	18.1	375	1		2929
HA	6	M	20	TN	3	1	20.9	405	1		3555
HA	6	M	20	TN	3	2	40.0	492	1		4889
HA	6	M	20	TN	3	3	26.9	318	1		3589
HA	6	M	20	TN	9	1	21.8	305	1		2910
HA	6	M	20	TN	9	2	13.4	325	1		1837
HA	6	M	20	TN	9	3	22.4	309	1		3664
HA	7	M	30	DS	0	1	10.8	190	1		1342
HA	7	M	30	DS	0	2	13.9	262	1		1396
HA	7	M	30	DS	0	3	16.4	156	1		1312
HA	7	M	30	TK	1	1	15.8	168	1		1152
HA	7	M	30	TK	1	2	15.4	215	1		1473
HA	7	M	30	TK	1	3	10.0	229	1		1077
HA	7	M	30	TK	3	1	11.2	426	1		1984
HA	7	M	30	TK	3	2	11.6	121	1		772
HA	7	M	30	TK	3	3	16.0	170	1		1182
HA	7	M	30	TK	9	1	16.5	195	1		1760
HA	7	M	30	TK	9	2	19.1	363	2	158	2175
HA	7	M	30	TK	9	3	17.2	338	2	147	2492
HA	7	M	30	TN	1	1	20.8	274	1		1633
HA	7	M	30	TN	1	2	18.1	168	1		1269
HA	7	M	30	TN	1	3	11.2	330	1		1805
HA	7	M	30	TN	3	1	13.1	238	1		1334
HA	7	M	30	TN	3	2	11.2	364	1		1721
HA	7	M	30	TN	3	3	14.2	307	1		1861
HA	7	M	30	TN	9	1	19.4	323	1		2274
HA	7	M	30	TN	9	2	14.9	485	1		2401
HA	7	M	30	TN	9	3	11.0	210	1		1349
HA	8	F	20	DS	0	1	5.8	310	1		1355
HA	8	F	20	DS	0	2		263	2		1155
HA	8	F	20	DS	0	3	7.8	281	2	192	1220
HA	8	F	20	TK	1	1	14.6	405	1		2363
HA	8	F	20	TK	1	2	22.2	400	2	166	3206
HA	8	F	20	TK	1	3	9.2	210	1		1211
HA	8	F	20	TK	3	1	14.1	432	1		2488
HA	8	F	20	TK	3	2	20.4	281	1		2490
HA	8	F	20	TK	3	3	20.4	281	1		2490
HA	8	F	20	TK	9	1	29.8	376	1		3634
HA	8	F	20	TK	9	2	30.6	398	1		4861
HA	8	F	20	TK	9	3	32.6	399	1		3964
HA	8	F	20	TN	1	1	14.4	258	1		2126
HA	8	F	20	TN	1	2	13.4	307	1		1976
HA	8	F	20	TN	1	3	17.8	376	2	183	3281
HA	8	F	20	TN	3	1	22.7	479	2	184	4687
HA	8	F	20	TN	3	2	23.4	511	2	237	4493
HA	8	F	20	TN	3	3	27.3	376	2	165	4451
HA	8	F	20	TN	9	1	36.1	368	1		5048
HA	8	F	20	TN	9	2	31.1	492	2	148	5873
HA	8	F	20	TN	9	3	78.7	502	3	214	10191
HA	9	F	40	DS	0	1	14.0	264	1		1732
HA	9	F	40	DS	0	2	30.2	312	2	203	3007
HA	9	F	40	DS	0	3	13.1	441	2	175	2772
HA	9	F	40	TK	1	1	27.9	337	2	160	3098
HA	9	F	40	TK	1	2	10.1	653	2	130	3340
HA	9	F	40	TK	1	3	11.7	453	3	132	2413
HA	9	F	40	TK	3	1	20.7	306	2	136	2702
HA	9	F	40	TK	3	2	26.1	247	2	81	2593
HA	9	F	40	TK	3	3	19.8	374	3	115	2982
HA	9	F	40	TK	9	1	41.9	248	2	86	4548
HA	9	F	40	TK	9	2	37.7	391	2	133	5581
HA	9	F	40	TK	9	3	49.3	202	1		5113
HA	9	F	40	TN	1	1	21.1	456	2	217	4380
HA	9	F	40	TN	1	2	52.4	352	1		6352
HA	9	F	40	TN	1	3	28.3	321	1		4427
HA	9	F	40	TN	3	1	48.1	638	1		7705
HA	9	F	40	TN	3	2	42.1	410	2	156	5563
HA	9	F	40	TN	3	3	27.8	304	1		3117
HA	9	F	40	TN	9	1	147.6	519	3	154	15956
HA	9	F	40	TN	9	2	64.2	528	2	184	12319
HA	9	F	40	TN	9	3	57.4	462	2	151	8984
HA	10	F	40	DS	0	1	10.2	137	1		775
HA	10	F	40	DS	0	2	7.1	116	1		620
HA	10	F	40	DS	0	3	15.0	473	1		3095
HA	10	F	40	TK	1	1	10.9	258	2	103	1389
HA	10	F	40	TK	1	2	8.1	412	2	204	2051
HA	10	F	40	TK	1	3	7.8	164	1		839
HA	10	F	40	TK	3	1	7.4	161	1		877
HA	10	F	40	TK	3	2	6.8	352	2	182	1718
HA	10	F	40	TK	3	3	10.7	399	2	206	2324
HA	10	F	40	TK	9	1	15.0	198	1		1601
HA	10	F	40	TK	9	2	33.7	216	1		2929
HA	10	F	40	TK	9	3	19.0	383	1		2678
HA	10	F	40	TN	1	1	56.7	585	1		8496
HA	10	F	40	TN	1	2	36.4	436	1		5553
HA	10	F	40	TN	1	3	23.8	359	1		3474
HA	10	F	40	TN	3	1	41.7	522	2	223	4592
HA	10	F	40	TN	3	2	23.2	370	1		3106
HA	10	F	40	TN	3	3	45.4	646	2	375	7343
HA	10	F	40	TN	9	1	34.3	434	1		3764
HA	10	F	40	TN	9	2	11.9	338	2	123	2455
HA	10	F	40	TN	9	3	18.6	242	1		2236

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	11	M	20	DS	0	1	14.1	534	3	180	3018
HA	11	M	20	DS	0	2	7.9	147	1		789
HA	11	M	20	DS	0	3	14.9	507	2	387	3022
HA	11	M	20	TK	1	1	14.9	559	2	269	3653
HA	11	M	20	TK	1	2	23.4	459	2	274	3512
HA	11	M	20	TK	1	3	20.6	589	3	247	5637
HA	11	M	20	TK	3	1	20.5	532	3	261	4226
HA	11	M	20	TK	3	2	34.5	305	3	105	4968
HA	11	M	20	TK	3	3	27.5	572	2	395	4924
HA	11	M	20	TK	9	1	16.2	697	3	320	4733
HA	11	M	20	TK	9	2	17.0	643	3	274	5597
HA	11	M	20	TK	9	3	19.5	641	2	470	4068
HA	11	M	20	TN	1	1	21.7	534	2	267	3653
HA	11	M	20	TN	1	2	19.6	415	2	240	3062
HA	11	M	20	TN	1	3	17.4	779	2	600	3869
HA	11	M	20	TN	3	1	28.9	595	2	299	4464
HA	11	M	20	TN	3	2	14.1	720	4	342	4391
HA	11	M	20	TN	3	3	16.4	696	3	418	4285
HA	11	M	20	TN	9	1	16.0	483	2	116	3940
HA	11	M	20	TN	9	2	29.4	637	2	230	6694
HA	11	M	20	TN	9	3	21.4	706	3	295	7361
HA	12	F	20	DS	0	1	13.6	265	1		1835
HA	12	F	20	DS	0	2	6.0	126	1		570
HA	12	F	20	DS	0	3	9.4	177	1		1220
HA	12	F	20	TK	1	1	13.9	334	1		2690
HA	12	F	20	TK	1	2	8.0	481	3	195	2552
HA	12	F	20	TK	1	3	6.8	236	1		972
HA	12	F	20	TK	3	1	8.0	422	2	130	2063
HA	12	F	20	TK	3	2	23.2	609	3	184	3803
HA	12	F	20	TK	3	3	8.6	237	2	137	1263
HA	12	F	20	TK	9	1	16.2	238	2	101	2292
HA	12	F	20	TK	9	2	10.7	455	2	280	2768
HA	12	F	20	TK	9	3	21.3	561	2	127	4533
HA	12	F	20	TN	1	1	15.8	421	1		2629
HA	12	F	20	TN	1	2	24.6	256	1		2363
HA	12	F	20	TN	1	3	19.3	613	3	306	3506
HA	12	F	20	TN	3	1	24.5	454	2	177	3329
HA	12	F	20	TN	3	2	18.5	347	1		2637
HA	12	F	20	TN	3	3	23.4	316	1		2853
HA	12	F	20	TN	9	1	32.9	299	1		5209
HA	12	F	20	TN	9	2	41.9	688	2	236	7843
HA	12	F	20	TN	9	3	68.6	503	2	146	10733
HA	13	F	20	DS	0	1	15.6	349	2	93	3570
HA	13	F	20	DS	0	2	23.9	563	2	117	5406
HA	13	F	20	DS	0	3	14.6	133	1		1477
HA	13	F	20	TK	1	1	13.5	209	1		1894
HA	13	F	20	TK	1	2	11.2	536	2	281	4377
HA	13	F	20	TK	1	3	16.1	491	2	222	3934
HA	13	F	20	TK	3	1	13.8	712	3	223	4682
HA	13	F	20	TK	3	2	16.6	545	2	248	4890
HA	13	F	20	TK	3	3	15.3	424	2	214	3969
HA	13	F	20	TK	9	1	32.1	607	2	179	7119
HA	13	F	20	TK	9	2	17.4	570	2	112	5901
HA	13	F	20	TK	9	3	30.5	527	1		5746
HA	13	F	20	TN	1	1	32.2	489	2	94	7016
HA	13	F	20	TN	1	2	16.1	452	2	174	4303
HA	13	F	20	TN	1	3	21.8	523	3	165	5461
HA	13	F	20	TN	3	1	14.2	333	1		3662
HA	13	F	20	TN	3	2	14.8	594	2	231	5447
HA	13	F	20	TN	3	3	43.2	522	2	236	6119
HA	13	F	20	TN	9	1	31.5	759	3	175	7752
HA	13	F	20	TN	9	2	51.4	497	1		10258
HA	13	F	20	TN	9	3	32.2	484	2	196	8232
HA	14	F	20	DS	0	1	48.3	303	1		7844
HA	14	F	20	DS	0	2	23.1	382	2	96	3491
HA	14	F	20	DS	0	3	24.4	320	1		2889
HA	14	F	20	TK	1	1	20.2	275	1		2577
HA	14	F	20	TK	1	2	21.6	326	1		2799
HA	14	F	20	TK	1	3	33.4	322	2	69	4195
HA	14	F	20	TK	3	1	20.8	371	2	82	3426
HA	14	F	20	TK	3	2	24.9	244	1		2890
HA	14	F	20	TK	3	3	27.0	273	1		3151
HA	14	F	20	TK	9	1	30.5	423	2	106	5618
HA	14	F	20	TK	9	2	59.9	500	1		6821
HA	14	F	20	TK	9	3	51.6	364	1		7114
HA	14	F	20	TN	1	1	40.6	417	2	194	4563
HA	14	F	20	TN	1	2	51.6	402	2	203	5569
HA	14	F	20	TN	1	3	26.5	468	2	214	5302
HA	14	F	20	TN	3	1	32.0	489	2	161	5850
HA	14	F	20	TN	3	2	53.4	356	3	99	5968
HA	14	F	20	TN	3	3	23.8	480	3	128	5681
HA	14	F	20	TN	9	1	50.3	498	3	110	9570
HA	14	F	20	TN	9	2	45.8	596	4	88	10149
HA	14	F	20	TN	9	3	32.9	546	1		7826
HA	15	M	30	DS	0	1	18.1	577	4	196	2959
HA	15	M	30	DS	0	2	29.4	469	2	265	3367
HA	15	M	30	DS	0	3	20.1	401	2	208	2226
HA	15	M	30	TK	1	1	22.4	509	3	253	4178
HA	15	M	30	TK	1	2	18.7	564	2	287	3993
HA	15	M	30	TK	1	3	15.1	585	2	251	3932
HA	15	M	30	TK	3	1	13.2	664	3	280	3283
HA	15	M	30	TK	3	2	19.8	773	3	452	4218
HA	15	M	30	TK	3	3	47.6	626	2	390	4503
HA	15	M	30	TK	9	1	40.9	806	2	454	7825
HA	15	M	30	TK	9	2	67.0	714	2	401	9091
HA	15	M	30	TK	9	3	43.7	675	2	364	6971
HA	15	M	30	TN	1	1	36.2	498	2	306	4135
HA	15	M	30	TN	1	2	25.4	486	2	298	3711
HA	15	M	30	TN	1	3	19.1	517	2	332	4213
HA	15	M	30	TN	3	1	25.0	651	2	370	5715
HA	15	M	30	TN	3	2	33.2	590	2	361	7054
HA	15	M	30	TN	3	3	26.3	581	2	404	5786
HA	15	M	30	TN	9	1	48.2	606	2	423	8498
HA	15	M	30	TN	9	2	49.8	623	2	425	9223
HA	15	M	30	TN	9	3	31.8	647	2	401	6972

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	16	F	20	DS	0	1	50.2	259	1		6141
HA	16	F	20	DS	0	2	32.3	308	2	102	4273
HA	16	F	20	DS	0	3	37.6	267	1		3358
HA	16	F	20	TK	1	1	25.8	377	2	281	3438
HA	16	F	20	TK	1	2	20.2	483	2	217	3815
HA	16	F	20	TK	1	3	30.0	485	2	137	3817
HA	16	F	20	TK	3	1	20.6	522	2	258	3970
HA	16	F	20	TK	3	2	32.2	490	2	243	5443
HA	16	F	20	TK	3	3	24.1	615	2	217	5160
HA	16	F	20	TK	9	1	32.8	564	1		6372
HA	16	F	20	TK	9	2	53.0	378	2	165	6214
HA	16	F	20	TK	9	3	31.1	608	3	223	7218
HA	16	F	20	TN	1	1	38.7	701	2	147	9135
HA	16	F	20	TN	1	2	29.5	585	3	230	5863
HA	16	F	20	TN	1	3	61.4	500	2	130	7671
HA	16	F	20	TN	3	1	128.2	501	2	244	14610
HA	16	F	20	TN	3	2	61.5	479	2	158	9511
HA	16	F	20	TN	3	3	64.1	619	2	157	14450
HA	16	F	20	TN	9	1	152.5	560	3	189	24666
HA	16	F	20	TN	9	2	62.3	538	1		13364
HA	16	F	20	TN	9	3	37.0	536	2	300	8403
HA	17	F	20	DS	0	1	16.8	224	1		1975
HA	17	F	20	DS	0	2	21.2	286	1		2732
HA	17	F	20	DS	0	3	17.2	166	1		1692
HA	17	F	20	TK	1	1	14.5	296	1		2067
HA	17	F	20	TK	1	2	7.8	254	2	107	1523
HA	17	F	20	TK	1	3	20.6	292	1		1922
HA	17	F	20	TK	3	1	15.0	370	3	159	2516
HA	17	F	20	TK	3	2	12.9	449	2	78	2558
HA	17	F	20	TK	3	3	11.7	323	2	85	1807
HA	17	F	20	TK	9	1	15.9	370	2	107	2759
HA	17	F	20	TK	9	2	32.2	555	4	276	4505
HA	17	F	20	TK	9	3	16.2	290	2	133	2600
HA	17	F	20	TN	1	1	28.8	151	1		1820
HA	17	F	20	TN	1	2	26.0	324	1		2485
HA	17	F	20	TN	1	3	14.7	198	1		1460
HA	17	F	20	TN	3	1	37.8	388	1		3918
HA	17	F	20	TN	3	2	15.8	250	1		2220
HA	17	F	20	TN	3	3	13.7	319	1		1686
HA	17	F	20	TN	9	1	27.5	358	2	102	4252
HA	17	F	20	TN	9	2	51.8	504	1		7033
HA	17	F	20	TN	9	3	28.9	484	1		4683
HA	18	M	20	DS	0	1	74.6	630	2	445	7200
HA	18	M	20	DS	0	2	86.0	826	3	430	9331
HA	18	M	20	DS	0	3	42.0	797	3	406	7367
HA	18	M	20	TK	1	1	69.8	607	3	329	8759
HA	18	M	20	TK	1	2	49.0	594	2	409	8318
HA	18	M	20	TK	1	3	65.5	950	3	408	11145
HA	18	M	20	TK	3	1	36.6	760	3	280	8272
HA	18	M	20	TK	3	2	60.3	702	4	262	9372
HA	18	M	20	TK	3	3	46.3	707	2	427	7086
HA	18	M	20	TK	9	1	70.1	644	3	322	8917
HA	18	M	20	TK	9	2	53.1	755	3	281	9212
HA	18	M	20	TK	9	3	21.5	806	3	388	5813
HA	18	M	20	TN	1	1	73.2	747	3	466	10767
HA	18	M	20	TN	1	2	58.6	847	3	376	7963
HA	18	M	20	TN	1	3	73.7	729	2	432	10756
HA	18	M	20	TN	3	1	109.8	751	3	429	15369
HA	18	M	20	TN	3	2	105.8	706	2	404	15399
HA	18	M	20	TN	3	3	107.7	742	2	418	16852
HA	18	M	20	TN	9	1		1166	6		19381
HA	18	M	20	TN	9	2	78.0	782	2	514	18508
HA	18	M	20	TN	9	3	99.7	779	2	471	20034
HA	19	M	20	DS	0	1	13.0	497	2	355	2434
HA	19	M	20	DS	0	2	14.5	307	1		1829
HA	19	M	20	DS	0	3	18.4	223	1		1823
HA	19	M	20	TK	1	1	21.4	778	3	409	5451
HA	19	M	20	TK	1	2	15.1	812	2	555	4095
HA	19	M	20	TK	1	3	19.8	937	2	789	4466
HA	19	M	20	TK	3	1	10.5	222	1		1499
HA	19	M	20	TK	3	2	23.0	842	3	515	6207
HA	19	M	20	TK	3	3	16.9	805	3	485	5045
HA	19	M	20	TK	9	1	21.4	1312	3	1010	8716
HA	19	M	20	TK	9	2	14.5	876	3	576	5344
HA	19	M	20	TK	9	3	11.7	524	2	150	3270
HA	19	M	20	TN	1	1	8.6	477	2	251	2129
HA	19	M	20	TN	1	2	23.1	705	3	255	4636
HA	19	M	20	TN	1	3	13.5	643	2	516	3354
HA	19	M	20	TN	3	1	32.4	842	3	228	7707
HA	19	M	20	TN	3	2	22.0	480	3	214	4575
HA	19	M	20	TN	3	3	24.3	675	3	340	5493
HA	19	M	20	TN	9	1	35.9	425	3	133	5894
HA	19	M	20	TN	9	2	25.4	475	2	196	3728
HA	19	M	20	TN	9	3	25.8	571	3	137	5112
HA	20	F	20	DS	0	1	8.1	143	1		757
HA	20	F	20	DS	0	2	26.7	153	1		1786
HA	20	F	20	DS	0	3	8.8	183	1		906
HA	20	F	20	TK	1	1	14.9	211	1		1441
HA	20	F	20	TK	1	2	12.3	413	1		1730
HA	20	F	20	TK	1	3	10.1	229	1		1144
HA	20	F	20	TK	3	1	7.8	192	1		952
HA	20	F	20	TK	3	2	12.5	267	1		1507
HA	20	F	20	TK	3	3	9.3	202	1		996
HA	20	F	20	TK	9	1	15.5	272	1		1656
HA	20	F	20	TK	9	2	22.6	242	1		1946
HA	20	F	20	TK	9	3	15.4	311	1		2351
HA	20	F	20	TN	1	1	44.8	345	1		4275
HA	20	F	20	TN	1	2	30.3	277	1		3312
HA	20	F	20	TN	1	3	28.6	310	1		3914
HA	20	F	20	TN	3	1	43.2	282	1		4797
HA	20	F	20	TN	3	2	18.5	263	2	71	2466
HA	20	F	20	TN	3	3	27.9	289	1		3543
HA	20	F	20	TN	9	1	13.0	283	1		2187
HA	20	F	20	TN	9	2	19.0	301	1		2983
HA	20	F	20	TN	9	3	18.8	264	1		2609

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	21	M	20	DS	0	1	10.3	623	2	339	2687
HA	21	M	20	DS	0	2	24.9	503	3	183	3185
HA	21	M	20	DS	0	3	15.6	161	1		1178
HA	21	M	20	TK	1	1	11.8	478	3	186	2076
HA	21	M	20	TK	1	2	25.8	595	3	213	3289
HA	21	M	20	TK	1	3	23.2	532	2	402	3374
HA	21	M	20	TK	3	1	19.0	724	2	421	3220
HA	21	M	20	TK	3	2	32.2	765	2	465	5306
HA	21	M	20	TK	3	3	37.0	643	3	237	4486
HA	21	M	20	TK	9	1	27.4	578	2	413	3601
HA	21	M	20	TK	9	2	16.0	712	5	184	3796
HA	21	M	20	TK	9	3	22.9	554	2	428	2827
HA	21	M	20	TN	1	1	17.4	486	3	198	2398
HA	21	M	20	TN	1	2	46.8	872	4	373	8251
HA	21	M	20	TN	1	3	43.3	1031	3	465	8113
HA	21	M	20	TN	3	1	21.2	624	3	295	4296
HA	21	M	20	TN	3	2	66.6	972	3	449	10888
HA	21	M	20	TN	3	3	39.8	1010	4	470	8655
HA	21	M	20	TN	9	1	25.1	698	3	418	5565
HA	21	M	20	TN	9	2	41.7	792	3	427	8846
HA	21	M	20	TN	9	3	28.6	742	3	451	6560
HA	22	F	20	DS	0	1	17.0	202	1		1431
HA	22	F	20	DS	0	2	10.4	97	1		700
HA	22	F	20	DS	0	3	8.7	132	1		786
HA	22	F	20	TK	1	1	21.7	256	2	113	3198
HA	22	F	20	TK	1	2	9.1	336	1		1809
HA	22	F	20	TK	1	3	23.6	341	2	122	4040
HA	22	F	20	TK	3	1	22.2	401	2	192	3022
HA	22	F	20	TK	3	2	21.2	324	1		3106
HA	22	F	20	TK	3	3	19.6	345	1		2853
HA	22	F	20	TK	9	1	13.5	410	1		2984
HA	22	F	20	TK	9	2	10.6	297	1		1939
HA	22	F	20	TK	9	3	9.4	399	2	108	2317
HA	22	F	20	TN	1	1	30.6	370	3	119	4001
HA	22	F	20	TN	1	2	11.3	371	2	147	2520
HA	22	F	20	TN	1	3	14.9	379	3	151	3579
HA	22	F	20	TN	3	1	8.3	483	2	239	2307
HA	22	F	20	TN	3	2	10.2	173	1		1015
HA	22	F	20	TN	3	3	11.8	287	2	148	2444
HA	22	F	20	TN	9	1	23.0	410	1		5148
HA	22	F	20	TN	9	2	11.5	560	2	232	3231
HA	22	F	20	TN	9	3	10.9	485	1		2798
HA	23	F	40	DS	0	1	17.8	398	2	210	4236
HA	23	F	40	DS	0	2	36.6	386	3	260	4227
HA	23	F	40	DS	0	3	21.8	266	2	116	2188
HA	23	F	40	TK	1	1	17.1	130	2	34	1630
HA	23	F	40	TK	1	2	21.2	145	1		1658
HA	23	F	40	TK	1	3	17.7	504	2	380	2989
HA	23	F	40	TK	3	1	16.3	159	1		1364
HA	23	F	40	TK	3	2	16.2	135	1		1297
HA	23	F	40	TK	3	3	17.3	165	1		1690
HA	23	F	40	TK	9	1	15.8	192	1		1342
HA	23	F	40	TK	9	2	22.6	183	1		1861
HA	23	F	40	TK	9	3	19.9	145	1		1717
HA	23	F	40	TN	1	1	19.3	299	1		2591
HA	23	F	40	TN	1	2	18.8	213	2	84	2045
HA	23	F	40	TN	1	3	18.7	373	3	120	3428
HA	23	F	40	TN	3	1	19.1	346	3	180	3780
HA	23	F	40	TN	3	2	18.7	271	3	87	3089
HA	23	F	40	TN	3	3	19.8	243	1		2581
HA	23	F	40	TN	9	1	34.0	236	1		4270
HA	23	F	40	TN	9	2	37.7	305	2	40	5679
HA	23	F	40	TN	9	3	29.9	402	2	82	5151
HA	24	M	20	DS	0	1	22.8	299	2	157	4442
HA	24	M	20	DS	0	2	39.3	307	2	76	5179
HA	24	M	20	DS	0	3	13.3	341	3	131	2481
HA	24	M	20	TK	1	1	42.8	344	2	169	9046
HA	24	M	20	TK	1	2	61.8	348	2	45	10436
HA	24	M	20	TK	1	3	48.2	287	1		7365
HA	24	M	20	TK	3	1	42.3	344	3	74	8566
HA	24	M	20	TK	3	2	53.5	307	1		9544
HA	24	M	20	TK	3	3	73.9	322	1		11084
HA	24	M	20	TK	9	1	57.7	385	2	38	11758
HA	24	M	20	TK	9	2	59.3	347	2	62	12109
HA	24	M	20	TK	9	3	73.8	451	2	69	15319
HA	24	M	20	TN	1	1	34.3	335	1		6119
HA	24	M	20	TN	1	2	76.1	362	1		10815
HA	24	M	20	TN	1	3	74.2	365	2	69	11688
HA	24	M	20	TN	3	1	21.4	364	1		4744
HA	24	M	20	TN	3	2	20.3	362	2	79	4650
HA	24	M	20	TN	3	3	23.8	271	2	66	3738
HA	24	M	20	TN	9	1	25.7	334	2	120	5232
HA	24	M	20	TN	9	2	18.0	373	1		3762
HA	24	M	20	TN	9	3	22.2	363	1		4550
HA	25	F	30	DS	0	1	88.7	156	1		6762
HA	25	F	30	DS	0	2	61.9	236	1		5312
HA	25	F	30	DS	0	3	63.9	217	1		5977
HA	25	F	30	TK	1	1	39.7	315	1		6519
HA	25	F	30	TK	1	2	55.7	347	1		7402
HA	25	F	30	TK	1	3	128.6	297	1		15062
HA	25	F	30	TK	3	1	54.7	334	2	132	8722
HA	25	F	30	TK	3	2	99.3	294	1		10933
HA	25	F	30	TK	3	3	59.0	324	1		9202
HA	25	F	30	TK	9	1	57.3	334	4	155	9597
HA	25	F	30	TK	9	2	63.7	355	2	215	8437
HA	25	F	30	TK	9	3	70.0	356	3	168	9779
HA	25	F	30	TN	1	1	72.4	305	1		8732
HA	25	F	30	TN	1	2	57.7	238	2	78	6820
HA	25	F	30	TN	1	3	57.8	262	1		6777
HA	25	F	30	TN	3	1	69.6	279	2	69	10053
HA	25	F	30	TN	3	2	76.0	251	2	42	8969
HA	25	F	30	TN	3	3	78.0	261	2	36	10622
HA	25	F	30	TN	9	1	125.0	340	1		14689
HA	25	F	30	TN	9	2	93.2	230	2	94	11146
HA	25	F	30	TN	9	3	74.0	334	2	97	12316

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	26	M	30	DS	0	1	8.9	543	2	452	2841
HA	26	M	30	DS	0	2	8.9	451	2	333	1858
HA	26	M	30	DS	0	3	12.7	250	2	64	1831
HA	26	M	30	TK	1	1	8.3	542	2	424	2194
HA	26	M	30	TK	1	2	13.4	750	3	347	4330
HA	26	M	30	TK	1	3	9.3	774	2	554	3893
HA	26	M	30	TK	3	1	10.9	684	2	533	3370
HA	26	M	30	TK	3	2	10.3	996	5	366	4783
HA	26	M	30	TK	3	3	11.8	767	2	643	3765
HA	26	M	30	TK	9	1	15.8	857	4	302	4964
HA	26	M	30	TK	9	2	8.9	434	2	211	2221
HA	26	M	30	TK	9	3	10.3	429	2	331	2055
HA	26	M	30	TN	1	1	7.0	380	2	201	1899
HA	26	M	30	TN	1	2	8.0	157	1		929
HA	26	M	30	TN	1	3	11.0	603	3	245	3273
HA	26	M	30	TN	3	1	8.5	599	2	487	3141
HA	26	M	30	TN	3	2	8.4	334	2	232	1719
HA	26	M	30	TN	3	3	7.4	289	2	161	1535
HA	26	M	30	TN	9	1	11.9	471	2	228	2648
HA	26	M	30	TN	9	2	11.8	602	3	243	3356
HA	26	M	30	TN	9	3	10.5	227	2	76	1573
HA	27	M	30	DS	0	1	17.1	582	3	326	3779
HA	27	M	30	DS	0	2	21.0	120	1		1471
HA	27	M	30	DS	0	3	16.2	162	1		1493
HA	27	M	30	TK	1	1	16.0	649	2	480	3579
HA	27	M	30	TK	1	2	15.9	755	2	610	4080
HA	27	M	30	TK	1	3	16.2	798	2	519	3965
HA	27	M	30	TK	3	1	28.6	621	3	373	4500
HA	27	M	30	TK	3	2	23.3	194	1		2422
HA	27	M	30	TK	3	3	25.7	413	2	259	3389
HA	27	M	30	TK	9	1	26.9	733	3	445	4564
HA	27	M	30	TK	9	2	22.1	777	3	477	5156
HA	27	M	30	TK	9	3	18.9	729	2	569	4876
HA	27	M	30	TN	1	1	32.7	641	2	485	4542
HA	27	M	30	TN	1	2	14.5	519	2	423	2786
HA	27	M	30	TN	1	3	16.3	652	2	434	4028
HA	27	M	30	TN	3	1	14.2	660	2	514	4220
HA	27	M	30	TN	3	2	21.7	569	3	384	4356
HA	27	M	30	TN	3	3	14.6	700	2	499	4123
HA	27	M	30	TN	9	1	35.9	769	3	445	7105
HA	27	M	30	TN	9	2	24.6	712	2	568	5415
HA	27	M	30	TN	9	3	25.3	780	2	583	6086
HA	28	M	30	DS	0	1	40.8	594	2	430	4625
HA	28	M	30	DS	0	2	41.0	480	2	383	3970
HA	28	M	30	DS	0	3	30.7	615	2	427	4052
HA	28	M	30	TK	1	1	45.0	584	2	461	5223
HA	28	M	30	TK	1	2	25.7	653	3	321	4277
HA	28	M	30	TK	1	3	27.8	572	3	369	5033
HA	28	M	30	TK	3	1	18.7	579	3	285	3812
HA	28	M	30	TK	3	2	41.4	593	2	453	5963
HA	28	M	30	TK	3	3	22.2	615	3	284	3893
HA	28	M	30	TK	9	1	38.6	456	2	347	3981
HA	28	M	30	TK	9	2	37.9	592	3	340	5691
HA	28	M	30	TK	9	3	39.8	557	3	334	6230
HA	28	M	30	TN	1	1	24.6	558	2	459	3731
HA	28	M	30	TN	1	2	22.7	555	3	320	4047
HA	28	M	30	TN	1	3	21.7	647	2	372	4982
HA	28	M	30	TN	3	1	31.8	633	4	287	6542
HA	28	M	30	TN	3	2	34.2	546	3	375	5273
HA	28	M	30	TN	3	3	18.5	533	3	322	3811
HA	28	M	30	TN	9	1	29.7	493	2	370	5418
HA	28	M	30	TN	9	2	40.2	533	2	349	6098
HA	28	M	30	TN	9	3	82.6	549	2	363	10850
HA	29	M	30	DS	0	1	14.6	558	2	380	3935
HA	29	M	30	DS	0	2	30.6	649	3	353	5032
HA	29	M	30	DS	0	3		630	3		3797
HA	29	M	30	TK	1	1	41.0	636	3	369	5870
HA	29	M	30	TK	1	2	28.3	751	3	424	6203
HA	29	M	30	TK	1	3	75.7	797	3	400	9651
HA	29	M	30	TK	3	1	30.2	667	3	361	6713
HA	29	M	30	TK	3	2	50.2	719	2	586	7272
HA	29	M	30	TK	3	3	26.3	757	3	409	5446
HA	29	M	30	TK	9	1	51.2	700	2	498	9371
HA	29	M	30	TK	9	2	46.2	606	2	446	8993
HA	29	M	30	TK	9	3	33.5	749	3	487	9899
HA	29	M	30	TN	1	1	24.2	734	2	532	6831
HA	29	M	30	TN	1	2	30.6	782	3	411	7281
HA	29	M	30	TN	1	3	24.2	755	4	387	7292
HA	29	M	30	TN	3	1	30.1	596	3	360	5458
HA	29	M	30	TN	3	2	18.7	784	3	505	6194
HA	29	M	30	TN	3	3	57.6	639	2	515	9746
HA	29	M	30	TN	9	1	74.8	758	3	517	15159
HA	29	M	30	TN	9	2	71.6	764	2	538	12151
HA	29	M	30	TN	9	3	65.7	739	3	378	14921
HA	30	F	30	DS	0	1	14.3	204	1		1374
HA	30	F	30	DS	0	2	21.1	174	1		1612
HA	30	F	30	DS	0	3	28.5	143	1		2067
HA	30	F	30	TK	1	1	17.0	288	1		2952
HA	30	F	30	TK	1	2	19.8	274	2	158	2592
HA	30	F	30	TK	1	3	24.7	190	1		2217
HA	30	F	30	TK	3	1	12.2	319	2	162	2023
HA	30	F	30	TK	3	2	31.7	295	1		4360
HA	30	F	30	TK	3	3	24.0	332	1		3861
HA	30	F	30	TK	9	1	23.8	352	1		4093
HA	30	F	30	TK	9	2	21.9	387	1		4152
HA	30	F	30	TK	9	3	21.3	380	1		3886
HA	30	F	30	TN	1	1	17.4	217	1		2418
HA	30	F	30	TN	1	2	14.3	242	1		2315
HA	30	F	30	TN	1	3	15.5	283	1		2382
HA	30	F	30	TN	3	1	21.3	269	1		2861
HA	30	F	30	TN	3	2	28.6	227	1		2958
HA	30	F	30	TN	3	3	18.5	244	2	77	2279
HA	30	F	30	TN	9	1	46.6	391	1		6322
HA	30	F	30	TN	9	2	18.9	394	1		3507
HA	30	F	30	TN	9	3	15.5	242	2	69	2638

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	31	F	50	DS	0	1	11.8	254	2	98	1722
HA	31	F	50	DS	0	2	13.8	401	2	303	2718
HA	31	F	50	DS	0	3	19.4	298	2	231	2375
HA	31	F	50	TK	1	1	9.8	404	2	295	2541
HA	31	F	50	TK	1	2	13.5	342	2	233	2120
HA	31	F	50	TK	1	3	19.1	418	2	250	2918
HA	31	F	50	TK	3	1	17.0	379	2	99	3346
HA	31	F	50	TK	3	2	32.2	492	2	285	4539
HA	31	F	50	TK	3	3	9.6	280	2	160	1313
HA	31	F	50	TK	9	1	39.7	314	1		3991
HA	31	F	50	TK	9	2	42.2	288	1		4631
HA	31	F	50	TK	9	3	40.2	448	2	289	6105
HA	31	F	50	TN	1	1	7.8	317	2	224	1585
HA	31	F	50	TN	1	2	11.9	240	1		1992
HA	31	F	50	TN	1	3	12.3	258	2	87	1745
HA	31	F	50	TN	3	1	11.5	340	1		2387
HA	31	F	50	TN	3	2	17.4	302	1		2694
HA	31	F	50	TN	3	3	24.0	365	3	128	3794
HA	31	F	50	TN	9	1	40.1	357	2	154	5505
HA	31	F	50	TN	9	2	23.8	530	3	243	5123
HA	31	F	50	TN	9	3	29.7	443	3	200	5423
HA	32	M	70	DS	0	1	35.2	339	2	98	5070
HA	32	M	70	DS	0	2	11.5	347	2	112	2661
HA	32	M	70	DS	0	3	10.7	405	2	123	2602
HA	32	M	70	TK	1	1	18.3	251	1		2255
HA	32	M	70	TK	1	2	14.6	173	1		1596
HA	32	M	70	TK	1	3	15.1	752	2	627	3973
HA	32	M	70	TK	3	1	16.4	215	1		1890
HA	32	M	70	TK	3	2	11.7	276	1		1823
HA	32	M	70	TK	3	3	14.8	391	2	267	2767
HA	32	M	70	TK	9	1	15.4	199	1		1870
HA	32	M	70	TK	9	2	23.4	201	1		2333
HA	32	M	70	TK	9	3	18.2	196	1		2008
HA	32	M	70	TN	1	1	16.0	376	1		3443
HA	32	M	70	TN	1	2	47.6	314	1		7996
HA	32	M	70	TN	1	3	34.4	339	2	77	6352
HA	32	M	70	TN	3	1	46.9	402	1		8673
HA	32	M	70	TN	3	2	54.2	368	2	175	8319
HA	32	M	70	TN	3	3	34.0	391	3	76	7630
HA	32	M	70	TN	9	1	19.1	393	1		3949
HA	32	M	70	TN	9	2	11.2	474	1		3055
HA	32	M	70	TN	9	3	12.2	371	1		3013
HA	33	F	60	DS	0	1	69.6	348	2	174	10124
HA	33	F	60	DS	0	2	17.8	385	3	179	3370
HA	33	F	60	DS	0	3	12.3	543	3	221	3329
HA	33	F	60	TK	1	1	23.1	446	2	275	4221
HA	33	F	60	TK	1	2	44.3	403	2	199	5988
HA	33	F	60	TK	1	3	30.2	387	2	266	4990
HA	33	F	60	TK	3	1	55.9	175	1		3710
HA	33	F	60	TK	3	2	51.9	252	1		4700
HA	33	F	60	TK	3	3	22.2	349	2	219	2500
HA	33	F	60	TK	9	1	16.4	488	2	179	2975
HA	33	F	60	TK	9	2	33.7	314	2	189	3837
HA	33	F	60	TK	9	3	37.7	216	1		3466
HA	33	F	60	TN	1	1	77.8	434	2	201	13685
HA	33	F	60	TN	1	2	56.2	357	1		9439
HA	33	F	60	TN	1	3	60.2	218	1		7286
HA	33	F	60	TN	3	1	64.2	476	2	116	10786
HA	33	F	60	TN	3	2	77.8	372	2	91	11445
HA	33	F	60	TN	3	3	67.4	373	2	273	10739
HA	33	F	60	TN	9	1	93.5	405	3	177	15860
HA	33	F	60	TN	9	2	114.5	388	3	226	12594
HA	33	F	60	TN	9	3	73.8	383	2	246	12888
HA	34	F	40	DS	0	1	11.0	390	2	183	1910
HA	34	F	40	DS	0	2	9.3	334	2	220	1415
HA	34	F	40	DS	0	3	11.2	346	2	262	1736
HA	34	F	40	TK	1	1	16.2	422	2	232	2259
HA	34	F	40	TK	1	2	13.4	307	2	224	1885
HA	34	F	40	TK	1	3	19.8	269	3	148	1982
HA	34	F	40	TK	3	1	12.6	456	3	166	2515
HA	34	F	40	TK	3	2	15.3	485	2	244	2745
HA	34	F	40	TK	3	3	15.0	347	2	232	2028
HA	34	F	40	TK	9	1	24.2	414	2	307	3564
HA	34	F	40	TK	9	2	16.0	436	2	297	2895
HA	34	F	40	TK	9	3	29.0	392	2	255	4932
HA	34	F	40	TN	1	1	25.7	340	2	223	3863
HA	34	F	40	TN	1	2	15.1	346	2	199	2723
HA	34	F	40	TN	1	3	16.6	380	2	219	2434
HA	34	F	40	TN	3	1	35.8	385	3	141	5533
HA	34	F	40	TN	3	2	38.5	335	2	174	4637
HA	34	F	40	TN	3	3	28.7	366	2	173	4867
HA	34	F	40	TN	9	1	27.8	470	3	167	6056
HA	34	F	40	TN	9	2	30.5	468	2	149	6159
HA	34	F	40	TN	9	3	41.4	286	2	123	4698
HA	35	F	30	DS	0	1	10.4	174	2	61	1184
HA	35	F	30	DS	0	2	15.0	248	1		1745
HA	35	F	30	DS	0	3	12.7	144	1		1154
HA	35	F	30	TK	1	1	11.0	259	2	100	1782
HA	35	F	30	TK	1	2	8.9	283	2	116	1627
HA	35	F	30	TK	1	3	12.5	315	1		1644
HA	35	F	30	TK	3	1	15.1	289	2	84	2286
HA	35	F	30	TK	3	2	19.2	353	2	120	3489
HA	35	F	30	TK	3	3	14.5	287	2	184	2742
HA	35	F	30	TK	9	1	33.6	349	2	219	3098
HA	35	F	30	TK	9	2	33.8	210	2	75	3523
HA	35	F	30	TK	9	3	20.0	348	2	208	2944
HA	35	F	30	TN	1	1	14.2	299	1		2201
HA	35	F	30	TN	1	2	45.3	206	2	77	5085
HA	35	F	30	TN	1	3	29.2	297	1		3978
HA	35	F	30	TN	3	1	38.9	296	2	77	5882
HA	35	F	30	TN	3	2	33.7	402	3	182	4735
HA	35	F	30	TN	3	3	31.7	199	2	78	4018
HA	35	F	30	TN	9	1	41.8	439	2	306	8276
HA	35	F	30	TN	9	2	32.9	435	2	195	6418
HA	35	F	30	TN	9	3	27.2	427	3	180	5975

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	36	M	30	DS	0	1	44.2	482	3	130	6173
HA	36	M	30	DS	0	2	37.5	191	2	67	3242
HA	36	M	30	DS	0	3	17.0	399	2	182	2747
HA	36	M	30	TK	1	1	41.8	374	2	181	5581
HA	36	M	30	TK	1	2	36.3	464	3	224	6863
HA	36	M	30	TK	1	3	36.4	492	2	279	6119
HA	36	M	30	TK	3	1	45.4	526	3	198	10252
HA	36	M	30	TK	3	2	27.0	444	3	221	5878
HA	36	M	30	TK	3	3	59.0	434	3	162	8532
HA	36	M	30	TK	9	1	107.7	281	2	111	11575
HA	36	M	30	TK	9	2	65.0	481	2	322	9503
HA	36	M	30	TK	9	3	57.4	304	2	158	7141
HA	36	M	30	TN	1	1	49.5	388	2	194	8726
HA	36	M	30	TN	1	2	19.0	325	2	164	3186
HA	36	M	30	TN	1	3	34.6	510	4	145	7787
HA	36	M	30	TN	3	1	92.2	415	2	217	15545
HA	36	M	30	TN	3	2	76.9	418	2	218	15544
HA	36	M	30	TN	3	3	62.3	471	3	146	14437
HA	36	M	30	TN	9	1	117.4	399	2	218	20278
HA	36	M	30	TN	9	2	142.8	612	3	161	24832
HA	36	M	30	TN	9	3	147.4	512	4	208	24075
HA	37	M	30	DS	0	1	21.9	120	1		1633
HA	37	M	30	DS	0	2	24.4	115	1		1681
HA	37	M	30	DS	0	3	13.9	133	1		1179
HA	37	M	30	TK	1	1	16.3	101	1		1031
HA	37	M	30	TK	1	2	12.2	114	1		1039
HA	37	M	30	TK	1	3	10.0	66	1		565
HA	37	M	30	TK	3	1	11.7	149	1		949
HA	37	M	30	TK	3	2	12.6	736	2	604	4767
HA	37	M	30	TK	3	3	9.8	291	2	152	1599
HA	37	M	30	TK	9	1	17.1	669	2	565	4673
HA	37	M	30	TK	9	2		708	2		5094
HA	37	M	30	TK	9	3	31.8	684	2	563	6081
HA	37	M	30	TN	1	1	10.0	569	2	501	3451
HA	37	M	30	TN	1	2	28.9	859	2	630	6627
HA	37	M	30	TN	1	3	45.5	255	2	109	5900
HA	37	M	30	TN	3	1	90.7	190	2	70	11099
HA	37	M	30	TN	3	2	19.1	190	1		1989
HA	37	M	30	TN	3	3	22.2	810	2	604	7258
HA	37	M	30	TN	9	1	23.8	578	2	469	5219
HA	37	M	30	TN	9	2	19.1	356	2	261	3331
HA	37	M	30	TN	9	3	18.1	700	2	484	5029
HA	38	F	20	DS	0	1	50.6	252	2	168	6373
HA	38	F	20	DS	0	2	44.7	308	2	154	5813
HA	38	F	20	DS	0	3	47.8	260	3	111	5703
HA	38	F	20	TK	1	1	26.4	426	3	204	4933
HA	38	F	20	TK	1	2	58.0	377	3	177	9844
HA	38	F	20	TK	1	3	53.8	376	3	190	8620
HA	38	F	20	TK	3	1	56.9	251	2	75	7840
HA	38	F	20	TK	3	2	44.2	390	2	175	7765
HA	38	F	20	TK	3	3	31.1	291	1		5764
HA	38	F	20	TK	9	1	28.8	489	3	230	5808
HA	38	F	20	TK	9	2	34.9	458	2	151	5541
HA	38	F	20	TK	9	3	35.0	309	2	126	4477
HA	38	F	20	TN	1	1	45.9	643	4	289	9709
HA	38	F	20	TN	1	2	35.0	594	4	203	8489
HA	38	F	20	TN	1	3	37.6	648	4	233	9129
HA	38	F	20	TN	3	1	34.6	431	2	179	8387
HA	38	F	20	TN	3	2	42.4	467	2	152	8777
HA	38	F	20	TN	3	3	61.0	347	2	98	11182
HA	38	F	20	TN	9	1	65.5	440	2	149	12942
HA	38	F	20	TN	9	2	51.8	394	2	69	10268
HA	38	F	20	TN	9	3	39.2	538	3	179	7909
HA	39	M	30	DS	0	1	14.4	817	2	690	3834
HA	39	M	30	DS	0	2	30.2	78	1		1633
HA	39	M	30	DS	0	3	23.4	809	2	674	4149
HA	39	M	30	TK	1	1	39.2	107	1		2218
HA	39	M	30	TK	1	2	39.0	721	2	580	4403
HA	39	M	30	TK	1	3	24.2	745	3	491	4417
HA	39	M	30	TK	3	1	21.7	766	3	510	4652
HA	39	M	30	TK	3	2	44.8	798	2	653	5376
HA	39	M	30	TK	3	3	33.3	859	2	709	5229
HA	39	M	30	TK	9	1	26.4	784	2	648	4307
HA	39	M	30	TK	9	2	36.6	757	2	685	4431
HA	39	M	30	TK	9	3	22.8	842	2	740	3874
HA	39	M	30	TN	1	1	22.2	506	2	425	2847
HA	39	M	30	TN	1	2	33.7	837	3	375	5549
HA	39	M	30	TN	1	3	34.8	817	2	654	4640
HA	39	M	30	TN	3	1	29.0	835	2	679	4300
HA	39	M	30	TN	3	2	16.6	753	2	592	3324
HA	39	M	30	TN	3	3	28.2	86	1		1567
HA	39	M	30	TN	9	1	27.0	951	3	610	8281
HA	39	M	30	TN	9	2	41.7	738	3	481	7983
HA	39	M	30	TN	9	3	65.0	760	2	614	7850
HA	40	F	40	DS	0	1	10.2	291	2	142	1725
HA	40	F	40	DS	0	2	5.1	65	1		299
HA	40	F	40	DS	0	3	9.3	220	1		1178
HA	40	F	40	TK	1	1	9.4	172	1		990
HA	40	F	40	TK	1	2	9.1	266	2	107	1659
HA	40	F	40	TK	1	3	18.9	287	2	145	2922
HA	40	F	40	TK	3	1	17.2	309	1		3079
HA	40	F	40	TK	3	2	11.8	230	2	71	1952
HA	40	F	40	TK	3	3	11.7	284	3	87	2217
HA	40	F	40	TK	9	1	40.3	288	1		5978
HA	40	F	40	TK	9	2	55.0	324	1		6494
HA	40	F	40	TK	9	3	48.0	425	1		5670
HA	40	F	40	TN	1	1	34.6	307	1		4735
HA	40	F	40	TN	1	2	17.6	354	2	89	3327
HA	40	F	40	TN	1	3	32.2	238	1		3740
HA	40	F	40	TN	3	1	40.9	731	2	291	7307
HA	40	F	40	TN	3	2	60.1	422	1		8413
HA	40	F	40	TN	3	3	35.6	502	2	331	6761
HA	40	F	40	TN	9	1	68.6	364	2	45	10344
HA	40	F	40	TN	9	2	50.8	455	4	133	9132
HA	40	F	40	TN	9	3	56.3	316	1		8314

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	41	M	20	DS	0	1	25.5	513	2	277	4503
HA	41	M	20	DS	0	2	30.6	683	3	296	5455
HA	41	M	20	DS	0	3	24.2	444	3	217	4419
HA	41	M	20	TK	1	1	33.4	667	4	307	5908
HA	41	M	20	TK	1	2	25.9	695	3	312	5177
HA	41	M	20	TK	1	3	31.4	537	2	307	5122
HA	41	M	20	TK	3	1	24.3	1075	3	409	6594
HA	41	M	20	TK	3	2	20.5	668	3	333	4542
HA	41	M	20	TK	3	3	21.0	564	3	340	4011
HA	41	M	20	TK	9	1	20.3	777	4	338	4842
HA	41	M	20	TK	9	2	19.0	656	3	345	4488
HA	41	M	20	TK	9	3	20.1	660	3	338	4025
HA	41	M	20	TN	1	1	50.7	891	4	311	12392
HA	41	M	20	TN	1	2	34.6	873	3	341	7212
HA	41	M	20	TN	1	3	24.6	850	3	387	6976
HA	41	M	20	TN	3	1	37.9	775	3	304	9755
HA	41	M	20	TN	3	2	46.3	715	4	302	10777
HA	41	M	20	TN	3	3	29.1	856	4	347	10446
HA	41	M	20	TN	9	1	31.7	636	4	306	8056
HA	41	M	20	TN	9	2	40.7	622	3	329	7914
HA	41	M	20	TN	9	3	36.1	663	3	349	8090
HA	42	F	30	DS	0	1	64.2	170	2	27	6944
HA	42	F	30	DS	0	2	63.2	317	2	204	7201
HA	42	F	30	DS	0	3	29.7	339	2	55	4834
HA	42	F	30	TK	1	1	90.6	381	3	194	10302
HA	42	F	30	TK	1	2	79.2	370	2	188	10823
HA	42	F	30	TK	1	3	51.7	409	3	239	7803
HA	42	F	30	TK	3	1	57.7	429	3	201	9929
HA	42	F	30	TK	3	2	89.5	370	2	218	10888
HA	42	F	30	TK	3	3	94.0	368	3	176	14363
HA	42	F	30	TK	9	1	112.6	427	3	221	21200
HA	42	F	30	TK	9	2	75.1	414	3	196	15590
HA	42	F	30	TK	9	3	85.4	402	1		14183
HA	42	F	30	TN	1	1	50.0	391	1		9215
HA	42	F	30	TN	1	2	50.2	191	1		4910
HA	42	F	30	TN	1	3	36.4	738	2	338	7370
HA	42	F	30	TN	3	1	72.5	464	3	331	11653
HA	42	F	30	TN	3	2	50.3	719	3	274	10860
HA	42	F	30	TN	3	3	37.4	446	3	238	7018
HA	42	F	30	TN	9	1	84.8	699	3	384	18794
HA	42	F	30	TN	9	2	127.9	512	3	114	20857
HA	42	F	30	TN	9	3	86.9	479	4	154	21459
HA	43	F	30	DS	0	1	83.7	198	2	117	5648
HA	43	F	30	DS	0	2	42.1	269	2	111	3517
HA	43	F	30	DS	0	3	31.8	181	2	132	2317
HA	43	F	30	TK	1	1	20.2	523	4	230	6023
HA	43	F	30	TK	1	2	17.4	290	3	79	3451
HA	43	F	30	TK	1	3	33.8	256	3	93	4112
HA	43	F	30	TK	3	1	41.2	336	2	153	5683
HA	43	F	30	TK	3	2	73.4	310	4	121	8663
HA	43	F	30	TK	3	3	43.4	474	3	254	7819
HA	43	F	30	TK	9	1	45.0	500	4	111	11267
HA	43	F	30	TK	9	2	79.5	414	4	116	13178
HA	43	F	30	TK	9	3	69.0	562	3	141	16542
HA	43	F	30	TN	1	1	33.9	402	2	30	5671
HA	43	F	30	TN	1	2	24.5	341	1		3663
HA	43	F	30	TN	1	3	30.1	292	1		4099
HA	43	F	30	TN	3	1	52.6	281	1		7818
HA	43	F	30	TN	3	2	22.7	374	3	171	4910
HA	43	F	30	TN	3	3	23.3	383	4	140	4911
HA	43	F	30	TN	9	1	44.4	593	3	30	9908
HA	43	F	30	TN	9	2	27.0	539	5	132	7976
HA	43	F	30	TN	9	3	83.9	338	3	78	12599
HA	44	F	40	DS	0	1	30.6	500	2	191	6381
HA	44	F	40	DS	0	2	11.8	383	1		3006
HA	44	F	40	DS	0	3	16.2	150	1		1590
HA	44	F	40	TK	1	1	20.7	630	2	315	6259
HA	44	F	40	TK	1	2	19.9	483	2	290	4793
HA	44	F	40	TK	1	3	17.6	530	2	336	5974
HA	44	F	40	TK	3	1	25.8	494	2	357	5250
HA	44	F	40	TK	3	2	23.8	545	2	283	7003
HA	44	F	40	TK	3	3	16.6	603	2	339	4311
HA	44	F	40	TK	9	1	37.2	648	2	438	8505
HA	44	F	40	TK	9	2	28.7	619	2	354	7457
HA	44	F	40	TK	9	3	38.6	605	4	240	10505
HA	44	F	40	TN	1	1	17.4	420	1		4311
HA	44	F	40	TN	1	2	21.0	558	2	323	6962
HA	44	F	40	TN	1	3	30.1	527	3	223	6852
HA	44	F	40	TN	3	1	47.8	598	3	222	11598
HA	44	F	40	TN	3	2	52.3	523	2	230	11365
HA	44	F	40	TN	3	3	45.4	518	3	146	10232
HA	44	F	40	TN	9	1	63.6	629	2	214	16503
HA	44	F	40	TN	9	2	55.4	598	5	145	11670
HA	44	F	40	TN	9	3	49.5	380	3	115	9108
HA	45	F	40	DS	0	1	13.5	195	1		1868
HA	45	F	40	DS	0	2	13.4	202	1		1766
HA	45	F	40	DS	0	3	16.6	207	1		1830
HA	45	F	40	TK	1	1	11.8	328	2	117	2587
HA	45	F	40	TK	1	2	13.4	347	1		2946
HA	45	F	40	TK	1	3	14.4	151	1		1413
HA	45	F	40	TK	3	1	19.3	410	2	267	4375
HA	45	F	40	TK	3	2	34.6	243	1		3370
HA	45	F	40	TK	3	3	31.4	318	1		3553
HA	45	F	40	TK	9	1	38.6	472	3	232	6883
HA	45	F	40	TK	9	2	28.6	225	1		3005
HA	45	F	40	TK	9	3	29.2	270	1		4167
HA	45	F	40	TN	1	1	22.6	199	1		2513
HA	45	F	40	TN	1	2	17.3	195	1		2116
HA	45	F	40	TN	1	3	25.4	170	1		2415
HA	45	F	40	TN	3	1	16.1	202	1		2188
HA	45	F	40	TN	3	2	16.6	288	1		3029
HA	45	F	40	TN	3	3	34.3	240	1		3901
HA	45	F	40	TN	9	1	22.2	218	1		2921
HA	45	F	40	TN	9	2	31.7	244	1		4100
HA	45	F	40	TN	9	3	17.0	397	1		3972

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	46	M	40	DS	0	1	8.1	84	1		524
HA	46	M	40	DS	0	2	7.8	66	1		447
HA	46	M	40	DS	0	3	15.8	173	1		1462
HA	46	M	40	TK	1	1	10.8	320	1		2120
HA	46	M	40	TK	1	2	20.0	690	2	493	5886
HA	46	M	40	TK	1	3	16.6	643	2	466	4756
HA	46	M	40	TK	3	1	13.0	677	2	442	4781
HA	46	M	40	TK	3	2	15.8	1343	3	609	8353
HA	46	M	40	TK	3	3	21.0	629	2	519	5090
HA	46	M	40	TK	9	1	15.5	769	2	587	4579
HA	46	M	40	TK	9	2	9.0	107	1		760
HA	46	M	40	TK	9	3	10.9	235	1		1746
HA	46	M	40	TN	1	1	20.9	570	2	434	4712
HA	46	M	40	TN	1	2	16.6	674	2	387	5575
HA	46	M	40	TN	1	3	31.8	587	2	375	5779
HA	46	M	40	TN	3	1	22.5	534	2	382	4877
HA	46	M	40	TN	3	2	29.1	469	2	341	4577
HA	46	M	40	TN	3	3	60.0	253	2	126	7792
HA	46	M	40	TN	9	1	18.4	589	2	309	5074
HA	46	M	40	TN	9	2	14.6	84	1		321
HA	46	M	40	TN	9	3	25.8	397	3	234	4438
HA	47	F	30	DS	0	1	14.6	422	2	262	3317
HA	47	F	30	DS	0	2	14.5	104	1		1089
HA	47	F	30	DS	0	3	12.7	192	1		1619
HA	47	F	30	TK	1	1	7.5	135	2	77	863
HA	47	F	30	TK	1	2	11.8	122	1		973
HA	47	F	30	TK	1	3	8.6	282	2	154	1842
HA	47	F	30	TK	3	1	17.0	152	1		1701
HA	47	F	30	TK	3	2	19.0	463	2	273	4988
HA	47	F	30	TK	3	3	11.9	643	4	271	4389
HA	47	F	30	TK	9	1	18.7	387	2	197	3832
HA	47	F	30	TK	9	2	12.2	423	2	189	2977
HA	47	F	30	TK	9	3	10.6	278	2	166	2079
HA	47	F	30	TN	1	1	18.4	165	1		1814
HA	47	F	30	TN	1	2	11.6	223	1		1481
HA	47	F	30	TN	1	3	18.0	221	1		2333
HA	47	F	30	TN	3	1	12.6	276	2	140	2503
HA	47	F	30	TN	3	2	13.5	198	1		2046
HA	47	F	30	TN	3	3	11.8	289	1		2527
HA	47	F	30	TN	9	1	10.6	356	2	100	2779
HA	47	F	30	TN	9	2	10.6	344	3	125	2716
HA	47	F	30	TN	9	3	15.4	219	1		2716
HA	48	F	30	DS	0	1	19.6	281	2	138	2854
HA	48	F	30	DS	0	2	16.5	249	2	101	2412
HA	48	F	30	DS	0	3	17.0	357	2	155	2973
HA	48	F	30	TK	1	1	18.3	287	2	151	3242
HA	48	F	30	TK	1	2	16.5	296	2	90	2934
HA	48	F	30	TK	1	3	15.3	332	2	134	2965
HA	48	F	30	TK	3	1	18.5	376	4	124	3361
HA	48	F	30	TK	3	2	19.7	330	2	152	3451
HA	48	F	30	TK	3	3	11.4	370	1		2981
HA	48	F	30	TK	9	1	14.6	471	3	131	3729
HA	48	F	30	TK	9	2	13.5	345	1		3046
HA	48	F	30	TK	9	3	30.2	440	1		4954
HA	48	F	30	TN	1	1	12.1	353	1		3075
HA	48	F	30	TN	1	2	29.2	473	1		5212
HA	48	F	30	TN	1	3	21.5	289	2	110	4259
HA	48	F	30	TN	3	1	24.8	342	2	150	5169
HA	48	F	30	TN	3	2	25.8	226	1		3033
HA	48	F	30	TN	3	3	19.0	427	2	99	4364
HA	48	F	30	TN	9	1	18.4	600	3	174	6152
HA	48	F	30	TN	9	2	17.8	439	3	180	4562
HA	48	F	30	TN	9	3	14.8	529	4	153	4590
HA	49	F	30	DS	0	1	36.2	211	1		3031
HA	49	F	30	DS	0	2	24.6	295	1		3735
HA	49	F	30	DS	0	3	25.7	216	1		3044
HA	49	F	30	TK	1	1	42.0	344	1		6237
HA	49	F	30	TK	1	2	47.0	470	1		7896
HA	49	F	30	TK	1	3	76.0	230	1		7338
HA	49	F	30	TK	3	1	69.2	326	3	117	12948
HA	49	F	30	TK	3	2	64.2	303	3	97	10199
HA	49	F	30	TK	3	3	61.6	294	2	93	9640
HA	49	F	30	TK	9	1	53.9	424	2	142	10011
HA	49	F	30	TK	9	2	39.2	321	2	127	6459
HA	49	F	30	TK	9	3	41.0	275	1		5937
HA	49	F	30	TN	1	1	33.3	362	2	145	6982
HA	49	F	30	TN	1	2	51.3	374	2	125	9168
HA	49	F	30	TN	1	3	26.3	409	2	75	5048
HA	49	F	30	TN	3	1	25.4	402	2	148	6652
HA	49	F	30	TN	3	2	32.5	421	3	108	6846
HA	49	F	30	TN	3	3	46.2	444	2	172	6972
HA	49	F	30	TN	9	1	41.7	433	2	163	7839
HA	49	F	30	TN	9	2	65.2	457	2	173	11358
HA	49	F	30	TN	9	3	102.7	408	2	193	14395
HA	50	F	30	DS	0	1	22.4	181	2	37	2393
HA	50	F	30	DS	0	2	16.2	208	1		2113
HA	50	F	30	DS	0	3	15.0	72	1		800
HA	50	F	30	TK	1	1	23.6	299	1		4015
HA	50	F	30	TK	1	2	15.5	273	2	160	2627
HA	50	F	30	TK	1	3	19.0	424	3	157	4495
HA	50	F	30	TK	3	1	22.2	396	1		4221
HA	50	F	30	TK	3	2	32.4	337	3	107	6239
HA	50	F	30	TK	3	3	28.2	389	2	108	5541
HA	50	F	30	TK	9	1	46.3	344	2	190	6805
HA	50	F	30	TK	9	2	45.6	372	1		5540
HA	50	F	30	TK	9	3	86.6	318	1		9496
HA	50	F	30	TN	1	1	32.6	344	2	167	4715
HA	50	F	30	TN	1	2	53.4	357	3	77	9125
HA	50	F	30	TN	1	3	58.9	439	2	224	11828
HA	50	F	30	TN	3	1	71.7	442	4	120	13347
HA	50	F	30	TN	3	2		425	3		9588
HA	50	F	30	TN	3	3	100.7	315	3	93	13643
HA	50	F	30	TN	9	1	87.1	466	3	130	14815
HA	50	F	30	TN	9	2	88.9	418	2	23	12393
HA	50	F	30	TN	9	3	34.8	472	3	197	7763

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	51	M	40	DS	0	1	14.5	229	1		2020
HA	51	M	40	DS	0	2	17.1	922	2	712	5998
HA	51	M	40	DS	0	3	26.5	967	2	717	8067
HA	51	M	40	TK	1	1	14.3	312	1		2835
HA	51	M	40	TK	1	2	19.8	167	1		1692
HA	51	M	40	TK	1	3	21.1	492	1		5008
HA	51	M	40	TK	3	1	16.9	194	1		1611
HA	51	M	40	TK	3	2	23.7	805	2	653	6911
HA	51	M	40	TK	3	3	15.8	986	2	692	7794
HA	51	M	40	TK	9	1	25.6	1040	2	744	8533
HA	51	M	40	TK	9	2	29.9	854	2	685	7681
HA	51	M	40	TK	9	3	58.0	867	2	670	9610
HA	51	M	40	TN	1	1	19.3	326	1		2884
HA	51	M	40	TN	1	2	15.0	228	1		2100
HA	51	M	40	TN	1	3	23.9	170	1		2023
HA	51	M	40	TN	3	1	22.9	264	1		2668
HA	51	M	40	TN	3	2	27.7	988	2	769	11640
HA	51	M	40	TN	3	3	23.9	966	2	645	8550
HA	51	M	40	TN	9	1	38.2	169	1		2721
HA	51	M	40	TN	9	2	25.7	212	1		2611
HA	51	M	40	TN	9	3	23.1	978	2	558	9450
HA	52	M	50	DS	0	1	15.5	282	1		2340
HA	52	M	50	DS	0	2	11.0	114	1		1005
HA	52	M	50	DS	0	3	19.5	191	1		1912
HA	52	M	50	TK	1	1	17.6	478	1		4577
HA	52	M	50	TK	1	2	19.5	253	1		2791
HA	52	M	50	TK	1	3	18.4	479	2	150	4519
HA	52	M	50	TK	3	1	15.3	491	1		4223
HA	52	M	50	TK	3	2	23.4	332	2	128	3570
HA	52	M	50	TK	3	3	19.9	586	2	345	5275
HA	52	M	50	TK	9	1	18.8	775	3	175	6873
HA	52	M	50	TK	9	2	19.3	554	3	219	5786
HA	52	M	50	TK	9	3	21.8	380	2	200	4020
HA	52	M	50	TN	1	1	41.9	181	1		3298
HA	52	M	50	TN	1	2	83.5	254	2	32	6747
HA	52	M	50	TN	1	3	37.8	230	2	106	3727
HA	52	M	50	TN	3	1	19.8	275	2	137	3224
HA	52	M	50	TN	3	2	14.6	551	1		4780
HA	52	M	50	TN	3	3	15.8	334	2	142	3252
HA	52	M	50	TN	9	1	19.5	763	2	308	8337
HA	52	M	50	TN	9	2	29.6	742	3	261	11405
HA	52	M	50	TN	9	3	26.6	494	2	235	6634
HA	53	M	40	DS	0	1	62.8	318	1		5138
HA	53	M	40	DS	0	2	43.9	333	1		3787
HA	53	M	40	DS	0	3	49.0	309	1		4434
HA	53	M	40	TK	1	1	17.3	427	2	233	3510
HA	53	M	40	TK	1	2	33.1	193	1		2488
HA	53	M	40	TK	1	3	51.1	819	2	412	9024
HA	53	M	40	TK	3	1	44.8	816	2	467	10052
HA	53	M	40	TK	3	2	43.4	850	2	500	9020
HA	53	M	40	TK	3	3	32.2	766	3	447	7940
HA	53	M	40	TK	9	1	37.7	844	2	532	9420
HA	53	M	40	TK	9	2	45.8	860	2	599	9690
HA	53	M	40	TK	9	3	23.8	218	2	78	3134
HA	53	M	40	TN	1	1	37.7	311	1		3968
HA	53	M	40	TN	1	2	58.2	653	3	301	9152
HA	53	M	40	TN	1	3	53.0	786	2	539	10341
HA	53	M	40	TN	3	1	51.0	825	4	397	9578
HA	53	M	40	TN	3	2	53.6	772	2	612	10911
HA	53	M	40	TN	3	3	47.8	845	3	612	11424
HA	53	M	40	TN	9	1	59.4	905	2	564	14692
HA	53	M	40	TN	9	2	84.4	802	3	377	18637
HA	53	M	40	TN	9	3	91.3	983	5	511	20238
HA	54	M	70	DS	0	1	7.4	218	1		825
HA	54	M	70	DS	0	2	5.8	201	1		779
HA	54	M	70	DS	0	3	13.8	135	1		977
HA	54	M	70	TK	1	1	13.1	943	2	645	3806
HA	54	M	70	TK	1	2	8.0	1845	4	681	5653
HA	54	M	70	TK	1	3	8.8	134	1		736
HA	54	M	70	TK	3	1	14.6	733	2	588	3068
HA	54	M	70	TK	3	2	9.4	308	1		1413
HA	54	M	70	TK	3	3	5.9	670	2	568	2555
HA	54	M	70	TK	9	1	28.0	214	1		2227
HA	54	M	70	TK	9	2	11.5	159	1		892
HA	54	M	70	TK	9	3	7.3	579	2	480	2326
HA	54	M	70	TN	1	1	7.5	168	1		767
HA	54	M	70	TN	1	2	6.2	1984	3	1081	6987
HA	54	M	70	TN	1	3	6.2	312	1		1056
HA	54	M	70	TN	3	1	9.0	230	1		1336
HA	54	M	70	TN	3	2	9.8	1207	2	799	4487
HA	54	M	70	TN	3	3	7.8	136	1		604
HA	54	M	70	TN	9	1	13.7	155	1		1235
HA	54	M	70	TN	9	2	9.4	321	1		1582
HA	54	M	70	TN	9	3	7.2	873	2	759	3398
HA	55	M	60	DS	0	1	7.0	132	1		621
HA	55	M	60	DS	0	2	6.7	160	1		695
HA	55	M	60	DS	0	3	9.0	196	1		1007
HA	55	M	60	TK	1	1	12.6	294	1		1670
HA	55	M	60	TK	1	2	13.5	407	2	159	2203
HA	55	M	60	TK	1	3	8.2	188	1		1028
HA	55	M	60	TK	3	1	16.1	443	1		2670
HA	55	M	60	TK	3	2	11.1	423	2	277	2225
HA	55	M	60	TK	3	3	10.5	221	1		1638
HA	55	M	60	TK	9	1	10.2	183	1		1320
HA	55	M	60	TK	9	2	8.2	355	2	202	2098
HA	55	M	60	TK	9	3	11.0	488	1		2320
HA	55	M	60	TN	1	1	9.8	513	2	358	2504
HA	55	M	60	TN	1	2	11.9	297	1		1941
HA	55	M	60	TN	1	3	13.7	388	1		2493
HA	55	M	60	TN	3	1	7.2	586	3	259	2361
HA	55	M	60	TN	3	2	17.8	347	2	165	3100
HA	55	M	60	TN	3	3	22.6	225	2	44	2933
HA	55	M	60	TN	9	1	51.7	530	2	225	8452
HA	55	M	60	TN	9	2	43.4	563	2	307	6874
HA	55	M	60	TN	9	3	29.2	548	2	288	5267
HA	56	M	60	DS	0	1	8.2	144	1		785
HA	56	M	60	DS	0	2	13.6	170	1		878
HA	56	M	60	DS	0	3	19.8	292	1		1947
HA	56	M	60	TK	1	1	6.2	113	1		533
HA	56	M	60	TK	1	2	6.3	195	1		690
HA	56	M	60	TK	1	3	6.0	138	1		481
HA	56	M	60	TK	3	1	6.5	493	2	292	2103
HA	56	M	60	TK	3	2	8.7	126	1		744
HA	56	M	60	TK	3	3	8.1	191	1		769
HA	56	M	60	TK	9	1	7.9	134	1		756
HA	56	M	60	TK	9	2	7.4	331	1		1553
HA	56	M	60	TK	9	3	7.2	126	1		539
HA	56	M	60	TN	1	1	12.0	140	1		870
HA	56	M	60	TN	1	2	7.0	253	1		1081
HA	56	M	60	TN	1	3	9.8	283	1		1571
HA	56	M	60	TN	3	1	12.1	489	1		2850
HA	56	M	60	TN	3	2	8.5	124	1		629
HA	56	M	60	TN	3	3	9.3	282	1		1663
HA	56	M	60	TN	9	1	8.1	329	1		1618
HA	56	M	60	TN	9	2	6.5	192	1		929
HA	56	M	60	TN	9	3	5.8	130	1		552
HA	57	F	60	DS	0	1	15.9	194	1		1088
HA	57	F	60	DS	0	2	11.7	163	1		1296
HA	57	F	60	DS	0	3	9.7	133	1		842
HA	57	F	60	TK	1	1	16.6	417	2	302	3168
HA	57	F	60	TK	1	2	19.4	206	1		1826
HA	57	F	60	TK	1	3	17.4	276	1		2060
HA	57	F	60	TK	3	1	16.6	246	1		1925
HA	57	F	60	TK	3	2	15.8	418	2	142	3555
HA	57	F	60	TK	3	3	15.3	240	1		2150
HA	57	F	60	TK	9	1	28.8	538	3	209	4899
HA	57	F	60	TK	9	2	21.9	653	3	264	6372
HA	57	F	60	TK	9	3	24.8	565	3	264	5088
HA	57	F	60	TN	1	1	15.9	565	2	396	3994
HA	57	F	60	TN	1	2	48.2	463	3	199	5846
HA	57	F	60	TN	1	3	29.8	473	2	168	5225
HA	57	F	60	TN	3	1	27.6	630	3	218	5760
HA	57	F	60	TN	3	2	17.9	357	3	116	3241
HA	57	F	60	TN	3	3	27.0	379	2	178	4643
HA	57	F	60	TN	9	1	41.5	711	3	202	8432
HA	57	F	60	TN	9	2	20.1	505	2	400	4298
HA	57	F	60	TN	9	3	36.7	514	3	118	6515
HA	58	F	70	DS	0	1	14.5	473	2	138	3141
HA	58	F	70	DS	0	2	12.6	117	1		952
HA	58	F	70	DS	0	3	9.8	153	2	53	1019
HA	58	F	70	TK	1	1	19.2	315	1		1964
HA	58	F	70	TK	1	2	11.7	364	1		1761
HA	58	F	70	TK	1	3	23.0	299	2	129	2809
HA	58	F	70	TK	3	1	12.2	261	1		1686
HA	58	F	70	TK	3	2	8.2	108	1		562
HA	58	F	70	TK	3	3	18.6	490	2	206	4268
HA	58	F	70	TK	9	1	23.3	246	1		2814
HA	58	F	70	TK	9	2	24.1	448	3	158	4063
HA	58	F	70	TK	9	3	18.1	575	2	201	3499
HA	58	F	70	TN	1	1	7.0	443	2	210	1724
HA	58	F	70	TN	1	2	6.8	387	2	214	1481
HA	58	F	70	TN	1	3	9.0	254	1		1233
HA	58	F	70	TN	3	1	9.4	495	2	86	2532
HA	58	F	70	TN	3	2	13.4	585	3	152	3266
HA	58	F	70	TN	3	3	5.8	217	1		799
HA	58	F	70	TN	9	1	9.2	291	1		1439
HA	58	F	70	TN	9	2	20.8	500	1		3869
HA	58	F	70	TN	9	3	11.8	388	1		2430
HA	59	M	70	DS	0	1	7.5	219	1		861
HA	59	M	70	DS	0	2	8.4	229	1		1085
HA	59	M	70	DS	0	3	4.6	93	1		306
HA	59	M	70	TK	1	1	6.7	257	1		969
HA	59	M	70	TK	1	2	16.1	337	1		1673
HA	59	M	70	TK	1	3	8.1	231	1		944
HA	59	M	70	TK	3	1	8.6	208	1		740
HA	59	M	70	TK	3	2	14.2	146	1		996
HA	59	M	70	TK	3	3	13.1	266	1		1283
HA	59	M	70	TK	9	1	11.1	389	1		1861
HA	59	M	70	TK	9	2	11.8	343	1		2069
HA	59	M	70	TK	9	3	10.1	227	1		1096
HA	59	M	70	TN	1	1	11.8	247	2	125	1295
HA	59	M	70	TN	1	2	19.4	347	1		2860
HA	59	M	70	TN	1	3	13.3	194	2	93	1220
HA	59	M	70	TN	3	1	13.6	389	2	191	1715
HA	59	M	70	TN	3	2	8.6	378	2	136	1628
HA	59	M	70	TN	3	3	16.6	412	1		2934
HA	59	M	70	TN	9	1	16.9	252	2	76	2058
HA	59	M	70	TN	9	2	24.3	427	2	119	4707
HA	59	M	70	TN	9	3	23.3	600	2	247	4499
HA	60	F	70	DS	0	1	8.2	85	1		490
HA	60	F	70	DS	0	2	3.8	105	1		218
HA	60	F	70	DS	0	3	8.1	334	2	255	1067
HA	60	F	70	TK	1	1	13.6	574	2	393	2283
HA	60	F	70	TK	1	2	4.3	110	1		283
HA	60	F	70	TK	1	3	9.7	146	1		634
HA	60	F	70	TK	3	1	12.5	133	1		725
HA	60	F	70	TK	3	2	26.0	577	2	362	2943
HA	60	F	70	TK	3	3	13.8	125	1		806
HA	60	F	70	TK	9	1	14.7	305	1		1387
HA	60	F	70	TK	9	2	14.4	198	1		1122
HA	60	F	70	TK	9	3	12.2	242	1		1121
HA	60	F	70	TN	1	1	5.4	144	1		442
HA	60	F	70	TN	1	2	17.6	158	1		1419
HA	60	F	70	TN	1	3	12.2	171	1		1188
HA	60	F	70	TN	3	1	12.1	308	2	100	1600
HA	60	F	70	TN	3	2	9.3	476	2	351	2022
HA	60	F	70	TN	3	3	18.1	297	1		1882
HA	60	F	70	TN	9	1	36.6	460	4	86	6299
HA	60	F	70	TN	9	2	20.7	354	2	90	3890
HA	60	F	70	TN	9	3	14.8	290	1		2043

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	61	F	60	DS	0	1	6.2	114	1		502
HA	61	F	60	DS	0	2	4.8	79	1		252
HA	61	F	60	DS	0	3	6.8	78	1		387
HA	61	F	60	TK	1	1	12.0	439	2	246	1962
HA	61	F	60	TK	1	2	7.0	530	2	327	1788
HA	61	F	60	TK	1	3	14.6	536	2	349	2389
HA	61	F	60	TK	3	1	17.4	458	2	303	3183
HA	61	F	60	TK	3	2	27.8	486	2	368	3567
HA	61	F	60	TK	3	3	27.0	442	2	53	4484
HA	61	F	60	TK	9	1	30.6	410	2		3247
HA	61	F	60	TK	9	2	21.0	303	1		2639
HA	61	F	60	TK	9	3	20.6	236	1		2409
HA	61	F	60	TN	1	1	7.6	234	2	70	1198
HA	61	F	60	TN	1	2	13.8	226	1		1346
HA	61	F	60	TN	1	3	4.7	71	1		241
HA	61	F	60	TN	3	1	11.6	323	2	157	2291
HA	61	F	60	TN	3	2	12.7	312	1		1916
HA	61	F	60	TN	3	3	14.6	252	1		1846
HA	61	F	60	TN	9	1	5.4	295	1		1090
HA	61	F	60	TN	9	2	9.7	318	1		1524
HA	61	F	60	TN	9	3	9.6	307	1		1977
HA	62	F	70	DS	0	1	16.9	468	1		3675
HA	62	F	70	DS	0	2	8.7	408	2		1131
HA	62	F	70	DS	0	3	11.1	102	1		701
HA	62	F	70	TK	1	1	10.6	702	2	540	2473
HA	62	F	70	TK	1	2	7.8	354	2	221	1187
HA	62	F	70	TK	1	3	6.8	409	2	276	1244
HA	62	F	70	TK	3	1	5.6	844	2		2165
HA	62	F	70	TK	3	2	5.4	111	1		371
HA	62	F	70	TK	3	3	5.5	551	2	370	1331
HA	62	F	70	TK	9	1	9.4	457	3	249	1850
HA	62	F	70	TK	9	2	14.5	533	2	361	2444
HA	62	F	70	TK	9	3	13.8	475	2		2021
HA	62	F	70	TN	1	1	6.2	599	2		1644
HA	62	F	70	TN	1	2	7.0	733	2	576	2250
HA	62	F	70	TN	1	3	8.4	465	3	98	2017
HA	62	F	70	TN	3	1	15.4	528	2		2892
HA	62	F	70	TN	3	2	25.0	487	3	184	4407
HA	62	F	70	TN	3	3	10.2	909	4	179	3479
HA	62	F	70	TN	9	1	31.7	497	3		4742
HA	62	F	70	TN	9	2	31.9	500	3	133	5650
HA	62	F	70	TN	9	3	21.3	439	3	202	5699
HA	63	F	60	DS	0	1	5.9	536	2	304	1824
HA	63	F	60	DS	0	2	5.8	107	1		487
HA	63	F	60	DS	0	3	2.9	244	2	226	276
HA	63	F	60	TK	1	1	5.4	142	1		629
HA	63	F	60	TK	1	2	4.2	61	1		221
HA	63	F	60	TK	1	3	6.6	190	1		901
HA	63	F	60	TK	3	1	10.2	156	1		880
HA	63	F	60	TK	3	2	5.4	120	1		448
HA	63	F	60	TK	3	3	13.5	195	1		1399
HA	63	F	60	TK	9	1	10.0	169	1		1013
HA	63	F	60	TK	9	2	6.6	171	1		511
HA	63	F	60	TK	9	3	8.1	162	1		802
HA	63	F	60	TN	1	1	5.1	93	1		372
HA	63	F	60	TN	1	2	7.0	352	2	228	1430
HA	63	F	60	TN	1	3	6.5	116	1		553
HA	63	F	60	TN	3	1	7.8	352	2		1510
HA	63	F	60	TN	3	2	10.6	379	2	87	2451
HA	63	F	60	TN	3	3	16.2	426	1		2650
HA	63	F	60	TN	9	1	9.4	290	2	135	1532
HA	63	F	60	TN	9	2	5.0	264	2	131	910
HA	63	F	60	TN	9	3	7.3	369	2	214	1524
HA	64	M	70	DS	0	1	32.8	659	2	524	4225
HA	64	M	70	DS	0	2	21.4	805	2	562	3418
HA	64	M	70	DS	0	3	15.7	590	3	338	2620
HA	64	M	70	TK	1	1	6.8	227	2	118	928
HA	64	M	70	TK	1	2	7.9	368	2	229	1317
HA	64	M	70	TK	1	3	6.5	394	2		939
HA	64	M	70	TK	3	1	15.7	412	2	311	1701
HA	64	M	70	TK	3	2	12.9	196	1		1000
HA	64	M	70	TK	3	3	8.6	137	1		572
HA	64	M	70	TK	9	1	14.2	488	2	290	2550
HA	64	M	70	TK	9	2	7.1	420	2	302	1723
HA	64	M	70	TK	9	3	6.4	396	2	313	1242
HA	64	M	70	TN	1	1	6.4	810	3	425	2544
HA	64	M	70	TN	1	2	12.0	176	1		1143
HA	64	M	70	TN	1	3	5.7	452	2	305	1472
HA	64	M	70	TN	3	1	9.4	325	1		1693
HA	64	M	70	TN	3	2	9.4	560	3		2090
HA	64	M	70	TN	3	3	18.2	253	2	145	2437
HA	64	M	70	TN	9	1	15.4	280	1		2510
HA	64	M	70	TN	9	2	12.6	248	1		1872
HA	64	M	70	TN	9	3	26.2	254	1		3788
HA	65	M	70	DS	0	1	8.2	241	2		1207
HA	65	M	70	DS	0	2	5.2	348	2		747
HA	65	M	70	DS	0	3	3.2	72	1		147
HA	65	M	70	TK	1	1	10.1	413	2	232	1699
HA	65	M	70	TK	1	2	8.3	355	2	250	1483
HA	65	M	70	TK	1	3	7.8	145	1		805
HA	65	M	70	TK	3	1	5.6	141	1		460
HA	65	M	70	TK	3	2	14.8	415	2	211	2672
HA	65	M	70	TK	3	3	14.3	376	3	109	2975
HA	65	M	70	TK	9	1	10.6	167	1		1110
HA	65	M	70	TK	9	2	12.6	201	2		1385
HA	65	M	70	TK	9	3	10.0	233	1		1299
HA	65	M	70	TN	1	1	7.5	277	1		1350
HA	65	M	70	TN	1	2	7.8	306	1		1472
HA	65	M	70	TN	1	3	6.2	317	2		1216
HA	65	M	70	TN	3	1	17.0	285	1		2254
HA	65	M	70	TN	3	2	20.2	339	2	161	2382
HA	65	M	70	TN	3	3	12.6	357	1		1794
HA	65	M	70	TN	9	1	23.0	336	2	85	3720
HA	65	M	70	TN	9	2	8.8	379	2	199	1877
HA	65	M	70	TN	9	3	16.1	312	2		2327

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	66	F	60	DS	0	1	4.6	236	2	121	749
HA	66	F	60	DS	0	2	5.4	246	2	152	861
HA	66	F	60	DS	0	3	8.5	141	2	87	682
HA	66	F	60	TK	1	1	19.4	466	3	267	2832
HA	66	F	60	TK	1	2	7.8	462	3	227	1591
HA	66	F	60	TK	1	3	15.8	214	1		1752
HA	66	F	60	TK	3	1	20.3	246	2	69	2182
HA	66	F	60	TK	3	2	16.7	288	1		1929
HA	66	F	60	TK	3	3	18.6	493	3	213	3130
HA	66	F	60	TK	9	1	9.2	548	2	372	1941
HA	66	F	60	TK	9	2	12.7	478	2	314	2319
HA	66	F	60	TK	9	3	12.6	1376	3	735	4350
HA	66	F	60	TN	1	1	10.0	439	2	227	2508
HA	66	F	60	TN	1	2	8.8	209	2	82	1022
HA	66	F	60	TN	1	3	10.3	253	1		1726
HA	66	F	60	TN	3	1	21.0	446	3	211	4075
HA	66	F	60	TN	3	2	26.2	449	1		3760
HA	66	F	60	TN	3	3	8.6	384	2	176	1731
HA	66	F	60	TN	9	1	21.8	328	1		3294
HA	66	F	60	TN	9	2	12.3	322	1		2034
HA	66	F	60	TN	9	3	14.5	320	2	139	2878
HA	67	M	70	DS	0	1	8.8	176	1		1104
HA	67	M	70	DS	0	2	12.4	126	1		1004
HA	67	M	70	DS	0	3	13.0	373	2		2764
HA	67	M	70	TK	1	1	20.2	819	2	666	5412
HA	67	M	70	TK	1	2	14.9	919	2	733	5464
HA	67	M	70	TK	1	3	9.6	143	1		972
HA	67	M	70	TK	3	1	9.4	66	1		562
HA	67	M	70	TK	3	2	14.6	130	1		1168
HA	67	M	70	TK	3	3	13.4	120	1		1123
HA	67	M	70	TK	9	1	28.6	213	1		2840
HA	67	M	70	TK	9	2	17.0	153	1		1565
HA	67	M	70	TK	9	3	24.9	171	1		2305
HA	67	M	70	TN	1	1	12.2	815	2		4687
HA	67	M	70	TN	1	2	22.1	1039	3		6927
HA	67	M	70	TN	1	3	11.0	743	2		4318
HA	67	M	70	TN	3	1	12.2	182	1		1631
HA	67	M	70	TN	3	2	18.2	200	1		1877
HA	67	M	70	TN	3	3	20.4	138	1		1748
HA	67	M	70	TN	9	1	12.6	871	2	710	5354
HA	67	M	70	TN	9	2	18.9	937	2	818	5954
HA	67	M	70	TN	9	3	13.4	235	2		2195
HA	68	F	50	DS	0	1	21.8	305	2		2879
HA	68	F	50	DS	0	2	11.0	348	2		2282
HA	68	F	50	DS	0	3	15.1	223	1		1736
HA	68	F	50	TK	1	1	13.1	160	1		1362
HA	68	F	50	TK	1	2	19.3	229	1		2209
HA	68	F	50	TK	1	3	12.0	314	1		2470
HA	68	F	50	TK	3	1	13.9	153	1		1407
HA	68	F	50	TK	3	2	11.1	350	2		2643
HA	68	F	50	TK	3	3	17.2	165	1		1696
HA	68	F	50	TK	9	1	26.8	151	1		2270
HA	68	F	50	TK	9	2	21.9	340	1		3410
HA	68	F	50	TK	9	3	28.8	338	1		4161
HA	68	F	50	TN	1	1	15.0	186	1		1818
HA	68	F	50	TN	1	2	14.6	305	1		2731
HA	68	F	50	TN	1	3	14.9	359	1		2916
HA	68	F	50	TN	3	1	38.1	394	2	204	5121
HA	68	F	50	TN	3	2	29.6	387	2	205	5094
HA	68	F	50	TN	3	3	18.6	500	2	143	4294
HA	68	F	50	TN	9	1	16.1	365	2		3414
HA	68	F	50	TN	9	2	30.2	200	1		3045
HA	68	F	50	TN	9	3	22.5	372	1		3980
HA	69	F	60	DS	0	1	23.3	369	1		4048
HA	69	F	60	DS	0	2	20.6	314	2	121	3975
HA	69	F	60	DS	0	3	21.9	235	2	67	3237
HA	69	F	60	TK	1	1	22.9	283	1		3103
HA	69	F	60	TK	1	2	27.8	441	3	148	5873
HA	69	F	60	TK	1	3	31.9	417	2		4375
HA	69	F	60	TK	3	1	31.9	417	2		4375
HA	69	F	60	TK	3	2	8.8	181	1		1268
HA	69	F	60	TK	3	3	11.3	98	1		789
HA	69	F	60	TK	9	1	11.5	745	3	405	4998
HA	69	F	60	TK	9	2	14.2	777	3	479	5597
HA	69	F	60	TK	9	3	11.5	332	2	153	2246
HA	69	F	60	TN	1	1	27.4	360	3		4168
HA	69	F	60	TN	1	2	13.2	489	2	124	3908
HA	69	F	60	TN	1	3	22.8	319	2		3469
HA	69	F	60	TN	3	1	19.8	161	1		1918
HA	69	F	60	TN	3	2	32.6	228	2		4263
HA	69	F	60	TN	3	3	13.5	469	4		3988
HA	69	F	60	TN	9	1	27.0	377	2	37	5454
HA	69	F	60	TN	9	2	57.0	356	3	135	9156
HA	69	F	60	TN	9	3	49.4	363	1		9757
HA	70	F	60	DS	0	1	10.1	283	2	193	1848
HA	70	F	60	DS	0	2	11.7	286	1		1696
HA	70	F	60	DS	0	3	8.8	327	2		2232
HA	70	F	60	TK	1	1	13.7	857	2	676	5363
HA	70	F	60	TK	1	2	16.6	225	1		2295
HA	70	F	60	TK	1	3	33.7	392	2		4529
HA	70	F	60	TK	3	1	20.0	352	3		3311
HA	70	F	60	TK	3	2	23.3	353	2		3853
HA	70	F	60	TK	3	3	27.0	363	3	26	4110
HA	70	F	60	TK	9	1	8.8	96	1		597
HA	70	F	60	TK	9	2	11.1	350	2	177	2451
HA	70	F	60	TK	9	3	12.2	239	1		1598
HA	70	F	60	TN	1	1	18.5	198	1		2279
HA	70	F	60	TN	1	2	7.6	102	1		699
HA	70	F	60	TN	1	3	13.0	209	1		1828
HA	70	F	60	TN	3	1	16.8	259	2	119	2677
HA	70	F	60	TN	3	2	12.6	236	1		1770
HA	70	F	60	TN	3	3	14.8	559	4		4151
HA	70	F	60	TN	9	1	16.3	295	1		2721
HA	70	F	60	TN	9	2	19.6	638	3		5910
HA	70	F	60	TN	9	3	19.6	496	2		4857

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	71	F	50	DS	0	1	12.0	199	2		1398
HA	71	F	50	DS	0	2	15.8	189	2		1739
HA	71	F	50	DS	0	3	17.0	182	1		1713
HA	71	F	50	TK	1	1	8.7	288	1		2128
HA	71	F	50	TK	1	2	9.3	156	1		1032
HA	71	F	50	TK	1	3	9.9	189	2		1374
HA	71	F	50	TK	3	1	8.1	98	1		590
HA	71	F	50	TK	3	2	8.3	66	1		465
HA	71	F	50	TK	3	3	10.8	264	2	132	1620
HA	71	F	50	TK	9	1	14.5	139	1		1365
HA	71	F	50	TK	9	2	10.8	128	1		1046
HA	71	F	50	TK	9	3	13.2	138	1		1186
HA	71	F	50	TN	1	1	18.3	249	1		2932
HA	71	F	50	TN	1	2	17.1	310	2	148	2932
HA	71	F	50	TN	1	3	17.9	305	1		3188
HA	71	F	50	TN	3	1	10.6	356	2	231	2814
HA	71	F	50	TN	3	2	19.4	369	2		3735
HA	71	F	50	TN	3	3	11.4	262	2	135	1877
HA	71	F	50	TN	9	1	21.9	347	3		4283
HA	71	F	50	TN	9	2	21.8	343	2		4382
HA	71	F	50	TN	9	3	23.1	317	1		4028
HA	72	F	50	DS	0	1	13.3	242	1		2034
HA	72	F	50	DS	0	2	8.7	179	1		1013
HA	72	F	50	DS	0	3	8.2	140	1		849
HA	72	F	50	TK	1	1	17.0	182	1		1624
HA	72	F	50	TK	1	2	10.6	353	1		2410
HA	72	F	50	TK	1	3	14.2	170	1		1440
HA	72	F	50	TK	3	1	14.6	297	1		2661
HA	72	F	50	TK	3	2	12.8	266	1		2113
HA	72	F	50	TK	3	3	16.3	321	1		2795
HA	72	F	50	TK	9	1	29.3	317	1		3721
HA	72	F	50	TK	9	2	31.5	278	1		3066
HA	72	F	50	TK	9	3	28.8	397	1		3657
HA	72	F	50	TN	1	1	11.0	232	1		1557
HA	72	F	50	TN	1	2	7.4	580	3	214	2661
HA	72	F	50	TN	1	3	10.5	337	1		2259
HA	72	F	50	TN	3	1	15.6	339	1		3122
HA	72	F	50	TN	3	2	18.7	348	1		3547
HA	72	F	50	TN	3	3	17.6	310	2	146	3540
HA	72	F	50	TN	9	1	34.9	360	1		5637
HA	72	F	50	TN	9	2	41.2	433	3	79	7756
HA	72	F	50	TN	9	3	38.5	430	2	69	6924
HA	73	F	70	DS	0	1	8.5	367	1		1306
HA	73	F	70	DS	0	2	8.6	293	1		1235
HA	73	F	70	DS	0	3	9.0	143	1		616
HA	73	F	70	TK	1	1	5.0	169	1		613
HA	73	F	70	TK	1	2	13.0	378	1		1846
HA	73	F	70	TK	1	3	8.4	319	2	154	1522
HA	73	F	70	TK	3	1	14.3	332	2	59	1932
HA	73	F	70	TK	3	2	16.6	474	2	308	2719
HA	73	F	70	TK	3	3	36.0	368	2	81	4947
HA	73	F	70	TK	9	1	22.7	396	1		3255
HA	73	F	70	TK	9	2	19.6	332	1		2017
HA	73	F	70	TK	9	3	17.0	357	2	127	3117
HA	73	F	70	TN	1	1	16.0	367	1		2391
HA	73	F	70	TN	1	2	22.8	364	2	173	3629
HA	73	F	70	TN	1	3	15.6	195	1		1190
HA	73	F	70	TN	3	1	10.4	400	2	207	2123
HA	73	F	70	TN	3	2	14.9	242	1		1769
HA	73	F	70	TN	3	3	19.5	249	1		1557
HA	73	F	70	TN	9	1	21.1	340	1		2644
HA	73	F	70	TN	9	2	23.0	346	1		3535
HA	73	F	70	TN	9	3	33.8	360	1		5509
HA	74	F	60	DS	0	1	5.8	138	1		389
HA	74	F	60	DS	0	2	7.6	145	1		573
HA	74	F	60	DS	0	3	14.3	337	1		1863
HA	74	F	60	TK	1	1	19.9	454	1		2530
HA	74	F	60	TK	1	2	19.6	496	2	82	3478
HA	74	F	60	TK	1	3	12.9	183	1		1087
HA	74	F	60	TK	3	1	17.5	457	2	169	3134
HA	74	F	60	TK	3	2	16.6	393	1		3165
HA	74	F	60	TK	3	3	23.1	513	2	165	3663
HA	74	F	60	TK	9	1	17.4	153	1		1524
HA	74	F	60	TK	9	2	16.0	440	2	190	3497
HA	74	F	60	TK	9	3	13.3	248	2	155	2212
HA	74	F	60	TN	1	1	18.3	317	1		1871
HA	74	F	60	TN	1	2	6.2	197	1		716
HA	74	F	60	TN	1	3	31.3	337	1		3212
HA	74	F	60	TN	3	1	20.5	259	1		2063
HA	74	F	60	TN	3	2	56.0	449	2	133	6481
HA	74	F	60	TN	3	3	18.1	252	1		2347
HA	74	F	60	TN	9	1	32.7	594	2	169	6013
HA	74	F	60	TN	9	2	31.1	550	2	223	5485
HA	74	F	60	TN	9	3	57.0	309	1		5451
HA	75	F	60	DS	0	1	6.2	97	1		317
HA	75	F	60	DS	0	2	5.8	197	1		557
HA	75	F	60	DS	0	3	7.8	118	1		462
HA	75	F	60	TK	1	1	32.3	369	1		3089
HA	75	F	60	TK	1	2	9.7	430	1		2179
HA	75	F	60	TK	1	3	11.2	338	1		2195
HA	75	F	60	TK	3	1	12.5	316	1		1970
HA	75	F	60	TK	3	2	8.4	321	1		1394
HA	75	F	60	TK	3	3	7.6	435	1		1721
HA	75	F	60	TK	9	1	25.3	462	1		4541
HA	75	F	60	TK	9	2	12.2	416	1		2147
HA	75	F	60	TK	9	3	11.7	460	1		2847
HA	75	F	60	TN	1	1	7.9	345	1		1807
HA	75	F	60	TN	1	2	6.2	412	1		1582
HA	75	F	60	TN	1	3	9.8	268	1		1507
HA	75	F	60	TN	3	1	13.4	210	1		2054
HA	75	F	60	TN	3	2	8.8	473	1		2462
HA	75	F	60	TN	3	3	13.9	396	1		2800
HA	75	F	60	TN	9	1	28.1	281	1		2472
HA	75	F	60	TN	9	2	21.0	651	1		4695
HA	75	F	60	TN	9	3	16.2	711	2	481	4645

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	76	F	60	DS	0	1	10.8	275	1		1430
HA	76	F	60	DS	0	2	16.9	218	2	44	1959
HA	76	F	60	DS	0	3	9.8	137	1		694
HA	76	F	60	TK	1	1	18.8	329	1		2681
HA	76	F	60	TK	1	2	25.4	251	1		2230
HA	76	F	60	TK	1	3	21.5	220	1		2166
HA	76	F	60	TK	3	1	17.0	304	1		2208
HA	76	F	60	TK	3	2	31.2	426	1		4025
HA	76	F	60	TK	3	3	24.8	273	1		3410
HA	76	F	60	TK	9	1	31.9	405	1		3813
HA	76	F	60	TK	9	2	32.7	379	1		3936
HA	76	F	60	TK	9	3	28.2	383	2	136	3887
HA	76	F	60	TN	1	1	23.4	485	3	118	4199
HA	76	F	60	TN	1	2	18.1	324	1		2525
HA	76	F	60	TN	1	3	34.4	378	1		4164
HA	76	F	60	TN	3	1	10.6	466	3	245	2445
HA	76	F	60	TN	3	2	14.2	412	2	153	2486
HA	76	F	60	TN	3	3	20.6	266	1		2266
HA	76	F	60	TN	9	1	31.6	398	2	93	5028
HA	76	F	60	TN	9	2	36.9	386	2	159	5946
HA	76	F	60	TN	9	3	15.2	575	3	211	3653
HA	77	M	60	DS	0	1	19.2	273	1		1719
HA	77	M	60	DS	0	2	19.2	273	1		1719
HA	77	M	60	DS	0	3	13.8	783	2	620	2889
HA	77	M	60	TK	1	1	38.7	215	1		2465
HA	77	M	60	TK	1	2	23.2	181	1		1696
HA	77	M	60	TK	1	3	39.2	265	1		2696
HA	77	M	60	TK	3	1	25.0	250	1		1945
HA	77	M	60	TK	3	2	26.0	188	1		1818
HA	77	M	60	TK	3	3	40.3	202	1		2511
HA	77	M	60	TK	9	1	53.7	252	1		3875
HA	77	M	60	TK	9	2	44.7	789	2	668	4866
HA	77	M	60	TK	9	3	20.1	957	2	721	4293
HA	77	M	60	TN	1	1	15.1	806	2	662	3291
HA	77	M	60	TN	1	2	24.6	194	1		1956
HA	77	M	60	TN	1	3	18.9	200	1		1627
HA	77	M	60	TN	3	1	36.4	142	1		2204
HA	77	M	60	TN	3	2	39.0	149	1		2437
HA	77	M	60	TN	3	3	40.2	270	1		2743
HA	77	M	60	TN	9	1	21.4	289	1		1777
HA	77	M	60	TN	9	2	16.1	236	1		1546
HA	77	M	60	TN	9	3	24.6	333	1		2159
HA	78	M	60	DS	0	1	10.7	265	1		2028
HA	78	M	60	DS	0	2	16.2	247	1		1983
HA	78	M	60	DS	0	3	9.6	142	1		956
HA	78	M	60	TK	1	1	17.8	226	1		1883
HA	78	M	60	TK	1	2	37.4	144	1		2353
HA	78	M	60	TK	1	3	18.4	137	1		1517
HA	78	M	60	TK	3	1	13.3	147	1		1135
HA	78	M	60	TK	3	2	20.8	289	1		1895
HA	78	M	60	TK	3	3	4.6	100	1		254
HA	78	M	60	TK	9	1	46.6	567	2	229	6559
HA	78	M	60	TK	9	2	17.0	160	1		1693
HA	78	M	60	TK	9	3	16.8	372	1		2976
HA	78	M	60	TN	1	1	20.9	265	1		2625
HA	78	M	60	TN	1	2	54.5	201	1		5460
HA	78	M	60	TN	1	3	43.0	255	2	36	5449
HA	78	M	60	TN	3	1	18.1	213	1		2097
HA	78	M	60	TN	3	2	28.6	326	1		3628
HA	78	M	60	TN	3	3	17.4	271	1		2122
HA	78	M	60	TN	9	1	21.4	304	1		3192
HA	78	M	60	TN	9	2	38.8	329	1		4144
HA	78	M	60	TN	9	3	29.4	165	1		2055
HA	79	M	70	DS	0	1	32.9	155	1		2363
HA	79	M	70	DS	0	2	15.9	1090	2	796	7205
HA	79	M	70	DS	0	3	33.6	200	1		2401
HA	79	M	70	TK	1	1	53.9	1055	2	784	12578
HA	79	M	70	TK	1	2	27.5	277	1		3087
HA	79	M	70	TK	1	3	19.6	954	2	727	7520
HA	79	M	70	TK	3	1	44.8	843	2	656	7887
HA	79	M	70	TK	3	2	33.4	946	2	704	8498
HA	79	M	70	TK	3	3	23.1	302	1		2722
HA	79	M	70	TK	9	1	34.1	806	2	672	7994
HA	79	M	70	TK	9	2	44.2	1028	2	742	9917
HA	79	M	70	TK	9	3	52.4	855	2	644	9204
HA	79	M	70	TN	1	1	20.7	802	2	582	5914
HA	79	M	70	TN	1	2	56.9	324	1		5884
HA	79	M	70	TN	1	3	35.0	944	2	638	8289
HA	79	M	70	TN	3	1	25.8	1141	3	498	9471
HA	79	M	70	TN	3	2	56.5	320	2	23	6258
HA	79	M	70	TN	3	3	30.3	1170	3	530	9221
HA	79	M	70	TN	9	1	74.0	1069	3	749	15045
HA	79	M	70	TN	9	2	59.1	1166	4	750	12875
HA	79	M	70	TN	9	3	63.9	348	1		7485
HA	80	F	70	DS	0	1	15.0	545	1		4650
HA	80	F	70	DS	0	2	13.4	495	1		3931
HA	80	F	70	DS	0	3	12.3	224	1		1775
HA	80	F	70	TK	1	1	28.7	369	2	53	4856
HA	80	F	70	TK	1	2	32.1	594	3	172	7279
HA	80	F	70	TK	1	3	23.0	586	2	251	6239
HA	80	F	70	TK	3	1	21.8	590	2	333	7297
HA	80	F	70	TK	3	2	16.4	627	2	218	6108
HA	80	F	70	TK	3	3	21.9	533	2	314	6348
HA	80	F	70	TK	9	1	33.4	641	3	180	9177
HA	80	F	70	TK	9	2	34.1	697	3	237	9556
HA	80	F	70	TK	9	3	45.8	587	2	236	11255
HA	80	F	70	TN	1	1	23.6	495	1		6375
HA	80	F	70	TN	1	2	15.2	531	1		4653
HA	80	F	70	TN	1	3	22.2	397	2	137	4727
HA	80	F	70	TN	3	1	27.1	352	1		4902
HA	80	F	70	TN	3	2	21.9	419	2	106	4641
HA	80	F	70	TN	3	3	27.2	597	1		5400
HA	80	F	70	TN	9	1	31.5	658	1		6523
HA	80	F	70	TN	9	2	85.2	400	3	29	10628
HA	80	F	70	TN	9	3	39.8	388	1		6267

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	81	F	70	DS	0	1	13.3	337	1		2770
HA	81	F	70	DS	0	2	11.2	120	1		742
HA	81	F	70	DS	0	3	9.0	142	1		857
HA	81	F	70	TK	1	1	14.7	216	1		1425
HA	81	F	70	TK	1	2	19.0	626	2	271	4524
HA	81	F	70	TK	1	3	19.0	296	1		2665
HA	81	F	70	TK	3	1	19.9	248	1		2937
HA	81	F	70	TK	3	2	17.4	231	1		1947
HA	81	F	70	TK	3	3	32.6	495	1		5585
HA	81	F	70	TK	9	1	29.0	344	1		4496
HA	81	F	70	TK	9	2	40.7	348	1		5722
HA	81	F	70	TK	9	3	55.3	336	1		6371
HA	81	F	70	TN	1	1	29.9	256	1		3259
HA	81	F	70	TN	1	2	30.0	328	1		3574
HA	81	F	70	TN	1	3	31.6	370	1		4401
HA	81	F	70	TN	3	1	41.3	325	1		5838
HA	81	F	70	TN	3	2	49.3	499	2	67	8018
HA	81	F	70	TN	3	3	47.8	621	3	248	9878
HA	81	F	70	TN	9	1	32.8	383	2	44	6161
HA	81	F	70	TN	9	2	37.0	489	1		6700
HA	81	F	70	TN	9	3	32.5	226	1		3723
HA	82	M	60	DS	0	1	12.7	227	1		1720
HA	82	M	60	DS	0	2	11.0	130	1		995
HA	82	M	60	DS	0	3	13.4	120	1		933
HA	82	M	60	TK	1	1	9.5	85	1		633
HA	82	M	60	TK	1	2	9.4	123	1		623
HA	82	M	60	TK	1	3	14.2	328	1		2256
HA	82	M	60	TK	3	1	16.2	235	1		1795
HA	82	M	60	TK	3	2	14.4	149	1		1206
HA	82	M	60	TK	3	3	13.3	133	1		1170
HA	82	M	60	TK	9	1	13.4	734	2	530	4538
HA	82	M	60	TK	9	2	17.0	124	1		1078
HA	82	M	60	TK	9	3	28.4	123	1		1766
HA	82	M	60	TN	1	1	27.6	477	1		4693
HA	82	M	60	TN	1	2	14.8	80	1		818
HA	82	M	60	TN	1	3	21.7	146	1		1540
HA	82	M	60	TN	3	1	12.3	115	1		884
HA	82	M	60	TN	3	2	8.8	136	1		750
HA	82	M	60	TN	3	3	34.2	349	1		4023
HA	82	M	60	TN	9	1	20.5	560	1		4810
HA	82	M	60	TN	9	2	33.4	448	2	140	5341
HA	82	M	60	TN	9	3	17.4	334	1		2496
HA	83	M	60	DS	0	1	12.7	227	1		1720
HA	83	M	60	DS	0	2	11.0	130	1		995
HA	83	M	60	DS	0	3	13.4	120	1		933
HA	83	M	60	TK	1	1	9.5	85	1		633
HA	83	M	60	TK	1	2	9.4	123	1		623
HA	83	M	60	TK	1	3	14.2	328	1		2256
HA	83	M	60	TK	3	1	16.2	235	1		1795
HA	83	M	60	TK	3	2	14.4	149	1		1206
HA	83	M	60	TK	3	3	13.3	133	1		1170
HA	83	M	60	TK	9	1	13.4	734	2	530	4538
HA	83	M	60	TK	9	2	17.0	124	1		1078
HA	83	M	60	TK	9	3	28.4	123	1		1766
HA	83	M	60	TN	1	1	27.6	477	1		4693
HA	83	M	60	TN	1	2	14.8	80	1		818
HA	83	M	60	TN	1	3	21.7	146	1		1540
HA	83	M	60	TN	3	1	12.3	115	1		884
HA	83	M	60	TN	3	2	8.8	136	1		750
HA	83	M	60	TN	3	3	34.2	808	2	654	6788
HA	83	M	60	TN	9	1	20.5	938	2	605	6755
HA	83	M	60	TN	9	2	33.4	807	3	533	7296
HA	83	M	60	TN	9	3	17.4	816	2	560	5155
HA	84	M	70	DS	0	1	34.6	361	3	160	6786
HA	84	M	70	DS	0	2	19.2	338	2	187	3594
HA	84	M	70	DS	0	3	26.1	482	2	231	4850
HA	84	M	70	TK	1	1	25.8	566	2	192	7091
HA	84	M	70	TK	1	2	10.7	416	2	270	2849
HA	84	M	70	TK	1	3	10.5	772	2	535	4943
HA	84	M	70	TK	3	1	59.9	476	3	175	13654
HA	84	M	70	TK	3	2	23.6	585	2	354	4716
HA	84	M	70	TK	3	3	14.6	489	2	271	3391
HA	84	M	70	TK	9	1	33.5	390	2	96	4662
HA	84	M	70	TK	9	2	22.0	646	2	164	5572
HA	84	M	70	TK	9	3	43.6	364	1		7212
HA	84	M	70	TN	1	1	23.0	414	3	148	5709
HA	84	M	70	TN	1	2	37.7	497	2	229	6762
HA	84	M	70	TN	1	3	44.9	382	3	59	7132
HA	84	M	70	TN	3	1	44.9	382	3	59	7132
HA	84	M	70	TN	3	2	9.6	171	1		1002
HA	84	M	70	TN	3	3	23.6	410	2	223	4203
HA	84	M	70	TN	9	1	51.4	372	2	76	8484
HA	84	M	70	TN	9	2	19.4	397	2	134	4123
HA	84	M	70	TN	9	3	9.1	395	2	251	2080
HA	85	F	70	DS	0	1	16.3	322	1		2741
HA	85	F	70	DS	0	2	15.4	412	2	185	2793
HA	85	F	70	DS	0	3	14.5	289	2	62	2501
HA	85	F	70	TK	1	1	38.8	258	1		4769
HA	85	F	70	TK	1	2	34.8	588	2	42	7950
HA	85	F	70	TK	1	3	37.0	510	2	329	7197
HA	85	F	70	TK	3	1	25.0	322	1		4524
HA	85	F	70	TK	3	2	21.8	527	3	226	5696
HA	85	F	70	TK	3	3	37.8	502	2	108	7788
HA	85	F	70	TK	9	1	40.2	617	3	322	8336
HA	85	F	70	TK	9	2	28.1	597	3	321	6822
HA	85	F	70	TK	9	3	26.1	526	3	161	7262
HA	85	F	70	TN	1	1	19.4	464	2	118	5365
HA	85	F	70	TN	1	2	28.6	508	1		5442
HA	85	F	70	TN	1	3	23.8	409	2	107	5510
HA	85	F	70	TN	3	1	23.2	551	1		6754
HA	85	F	70	TN	3	2	29.9	524	2	88	7400
HA	85	F	70	TN	3	3	30.2	490	2	129	6880
HA	85	F	70	TN	9	1	33.6	617	4	212	8674
HA	85	F	70	TN	9	2	33.4	589	2	405	8282
HA	85	F	70	TN	9	3	27.0	575	2	119	6125

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	86	M	20	DS	0	1	12.6	275	1		2094
HA	86	M	20	DS	0	2	7.4	104	1		532
HA	86	M	20	DS	0	3	10.5	208	1		1069
HA	86	M	20	TK	1	1	9.4	115	1		697
HA	86	M	20	TK	1	2	11.4	377	2	164	2450
HA	86	M	20	TK	1	3	8.2	328	1		2226
HA	86	M	20	TK	3	1	9.9	113	1		669
HA	86	M	20	TK	3	2	8.4	176	1		1086
HA	86	M	20	TK	3	3	45.0	420	1		5368
HA	86	M	20	TK	9	1	44.2	220	1		4543
HA	86	M	20	TK	9	2	19.8	318	1		3056
HA	86	M	20	TK	9	3	19.8	322	1		3584
HA	86	M	20	TN	1	1	16.9	225	1		1905
HA	86	M	20	TN	1	2	12.3	182	1		1273
HA	86	M	20	TN	1	3	17.9	211	1		1942
HA	86	M	20	TN	3	1	14.1	239	1		2212
HA	86	M	20	TN	3	2	13.1	127	1		1155
HA	86	M	20	TN	3	3	18.2	291	1		2742
HA	86	M	20	TN	9	1	31.1	475	1		4765
HA	86	M	20	TN	9	2	41.3	378	2	127	4386
HA	86	M	20	TN	9	3	21.0	213	1		2477
HA	87	M	70	DS	0	1	8.2	76	1		475
HA	87	M	70	DS	0	2	9.4	239	2	91	1506
HA	87	M	70	DS	0	3	7.6	149	1		820
HA	87	M	70	TK	1	1	13.8	217	1		1992
HA	87	M	70	TK	1	2	10.1	321	1		2182
HA	87	M	70	TK	1	3	10.1	321	1		2182
HA	87	M	70	TK	3	1	10.7	149	1		1221
HA	87	M	70	TK	3	2	10.7	232	1		1697
HA	87	M	70	TK	3	3	9.6	278	1		1886
HA	87	M	70	TK	9	1	10.6	181	1		1268
HA	87	M	70	TK	9	2	12.4	263	1		1863
HA	87	M	70	TK	9	3	11.5	126	1		1079
HA	87	M	70	TN	1	1	11.2	106	1		904
HA	87	M	70	TN	1	2	14.6	185	1		1990
HA	87	M	70	TN	1	3	14.9	151	1		1444
HA	87	M	70	TN	3	1	10.9	235	1		1800
HA	87	M	70	TN	3	2	18.2	211	1		2528
HA	87	M	70	TN	3	3	12.8	264	1		2310
HA	87	M	70	TN	9	1	16.9	374	1		4319
HA	87	M	70	TN	9	2	17.5	348	2	113	4173
HA	87	M	70	TN	9	3	15.5	370	1		3696
HA	88	M	50	DS	0	1	12.0	75	1		744
HA	88	M	50	DS	0	2	10.3	175	1		1116
HA	88	M	50	DS	0	3	9.6	143	1		1029
HA	88	M	50	TK	1	1	14.2	133	1		1161
HA	88	M	50	TK	1	2	11.4	301	1		1952
HA	88	M	50	TK	1	3	15.4	152	1		1531
HA	88	M	50	TK	3	1	11.3	221	1		1477
HA	88	M	50	TK	3	2	14.2	224	2	151	1748
HA	88	M	50	TK	3	3	14.8	275	2	144	1769
HA	88	M	50	TK	9	1	18.1	459	2	122	4193
HA	88	M	50	TK	9	2	18.6	318	2	129	3617
HA	88	M	50	TK	9	3	18.9	315	2	95	2994
HA	88	M	50	TN	1	1	20.2	802	2	642	4954
HA	88	M	50	TN	1	2	17.9	787	2	616	5065
HA	88	M	50	TN	1	3	14.9	873	2	666	5292
HA	88	M	50	TN	3	1	12.7	976	2	632	6143
HA	88	M	50	TN	3	2	9.7	357	2	222	2540
HA	88	M	50	TN	3	3	12.2	187	1		1459
HA	88	M	50	TN	9	1	9.4	241	1		1846
HA	88	M	50	TN	9	2	21.7	376	1		3813
HA	88	M	50	TN	9	3	15.7	261	1		2884
HA	89	M	50	DS	0	1	10.6	229	1		1557
HA	89	M	50	DS	0	2	9.4	210	1		1429
HA	89	M	50	DS	0	3	9.1	153	1		1052
HA	89	M	50	TK	1	1	15.6	156	2	43	1821
HA	89	M	50	TK	1	2	8.6	255	1		1273
HA	89	M	50	TK	1	3	11.7	296	2	248	2138
HA	89	M	50	TK	3	1	9.8	320	1		2323
HA	89	M	50	TK	3	2	9.0	137	1		1049
HA	89	M	50	TK	3	3	9.9	204	1		1501
HA	89	M	50	TK	9	1	15.0	250	1		2569
HA	89	M	50	TK	9	2	12.5	265	1		2163
HA	89	M	50	TK	9	3	14.1	291	1		2614
HA	89	M	50	TN	1	1	10.8	231	1		1835
HA	89	M	50	TN	1	2	18.6	182	1		1852
HA	89	M	50	TN	1	3	23.1	246	1		3165
HA	89	M	50	TN	3	1	11.0	326	2	134	2509
HA	89	M	50	TN	3	2	10.2	165	1		1168
HA	89	M	50	TN	3	3	9.2	131	1		983
HA	89	M	50	TN	9	1	14.5	207	1		1942
HA	89	M	50	TN	9	2	13.8	129	1		1274
HA	89	M	50	TN	9	3	16.8	218	1		2541
HA	90	M	40	DS	0	1	14.4	141	1		1068
HA	90	M	40	DS	0	2	17.8	734	2	572	4699
HA	90	M	40	DS	0	3	23.4	152	1		1633
HA	90	M	40	TK	1	1	13.2	731	2	461	4525
HA	90	M	40	TK	1	2	12.9	628	2	479	3601
HA	90	M	40	TK	1	3	12.8	761	2	556	4617
HA	90	M	40	TK	3	1	16.8	757	2	581	4640
HA	90	M	40	TK	3	2	12.1	684	2	541	3682
HA	90	M	40	TK	3	3	17.7	679	2	530	4715
HA	90	M	40	TK	9	1	16.2	155	1		1233
HA	90	M	40	TK	9	2	11.3	770	2	567	2827
HA	90	M	40	TK	9	3	14.8	117	1		1078
HA	90	M	40	TN	1	1	15.5	108	1		1109
HA	90	M	40	TN	1	2	13.0	738	2	508	4411
HA	90	M	40	TN	1	3	11.5	703	2	501	3908
HA	90	M	40	TN	3	1	15.0	870	2	605	5344
HA	90	M	40	TN	3	2	15.5	107	1		967
HA	90	M	40	TN	3	3	14.6	784	3	387	4518
HA	90	M	40	TN	9	1	17.4	251	1		1969
HA	90	M	40	TN	9	2	23.1	114	1		1441
HA	90	M	40	TN	9	3	14.2	156	1		1149

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	91	F	50	DS	0	1	18.2	383	1		4046
HA	91	F	50	DS	0	2	20.8	185	1		2580
HA	91	F	50	DS	0	3	14.9	276	2	181	2640
HA	91	F	50	TK	1	1	18.4	339	3	119	4256
HA	91	F	50	TK	1	2	11.9	442	3	204	3408
HA	91	F	50	TK	1	3	25.6	231	1		2716
HA	91	F	50	TK	3	1	29.1	228	1		3682
HA	91	F	50	TK	3	2	12.6	66	1		605
HA	91	F	50	TK	3	3	15.4	200	2	120	1898
HA	91	F	50	TK	9	1	30.4	277	1		4532
HA	91	F	50	TK	9	2	23.0	308	1		4104
HA	91	F	50	TK	9	3	18.2	307	1		3432
HA	91	F	50	TN	1	1	20.1	335	1		3721
HA	91	F	50	TN	1	2	33.8	262	1		4502
HA	91	F	50	TN	1	3	23.5	377	2	235	4539
HA	91	F	50	TN	3	1	20.5	368	1		4385
HA	91	F	50	TN	3	2	22.2	361	2	100	4976
HA	91	F	50	TN	3	3	29.3	283	1		4572
HA	91	F	50	TN	9	1	21.5	520	3	170	6221
HA	91	F	50	TN	9	2	21.4	303	2	99	3688
HA	91	F	50	TN	9	3	21.6	512	3	284	5803
HA	92	F	50	DS	0	1	18.7	286	2	121	2531
HA	92	F	50	DS	0	2	13.3	107	1		824
HA	92	F	50	DS	0	3	17.4	75	1		837
HA	92	F	50	TK	1	1	30.8	133	1		2294
HA	92	F	50	TK	1	2	33.0	173	2	47	3201
HA	92	F	50	TK	1	3	12.9	581	2	476	3514
HA	92	F	50	TK	3	1	29.0	199	1		3056
HA	92	F	50	TK	3	2	17.5	155	1		1694
HA	92	F	50	TK	3	3	19.6	151	1		1922
HA	92	F	50	TK	9	1	42.6	172	1		3436
HA	92	F	50	TK	9	2	46.9	212	1		4275
HA	92	F	50	TK	9	3	24.0	191	1		2646
HA	92	F	50	TN	1	1	32.8	302	3	101	5117
HA	92	F	50	TN	1	2	71.0	262	1		7781
HA	92	F	50	TN	1	3	81.2	233	2	78	10936
HA	92	F	50	TN	3	1	88.1	221	2	26	10191
HA	92	F	50	TN	3	2	69.9	222	2	55	7947
HA	92	F	50	TN	3	3	94.2	228	2	19	10193
HA	92	F	50	TN	9	1	78.9	296	2	43	11705
HA	92	F	50	TN	9	2	125.6	226	2	68	13531
HA	92	F	50	TN	9	3	80.2	231	3	34	9781
HA	93	F	50	DS	0	1	7.0	122	1		637
HA	93	F	50	DS	0	2	7.2	366	2	232	2009
HA	93	F	50	DS	0	3	8.2	136	1		925
HA	93	F	50	TK	1	1	7.0	100	1		624
HA	93	F	50	TK	1	2	9.5	236	1		1639
HA	93	F	50	TK	1	3	9.5	242	1		1531
HA	93	F	50	TK	3	1	16.6	424	2	295	3682
HA	93	F	50	TK	3	2	8.3	129	1		670
HA	93	F	50	TK	3	3	9.9	98	1		695
HA	93	F	50	TK	9	1	19.8	157	1		1674
HA	93	F	50	TK	9	2	16.8	92	1		1016
HA	93	F	50	TK	9	3	19.7	160	1		1594
HA	93	F	50	TN	1	1	29.6	295	2	68	4820
HA	93	F	50	TN	1	2	17.9	334	2	176	3509
HA	93	F	50	TN	1	3	16.3	299	1		3246
HA	93	F	50	TN	3	1	17.1	259	2	153	2466
HA	93	F	50	TN	3	2	18.7	354	2	107	3896
HA	93	F	50	TN	3	3	27.5	324	1		4011
HA	93	F	50	TN	9	1	43.0	319	2	195	5440
HA	93	F	50	TN	9	2	30.0	404	3	137	5732
HA	93	F	50	TN	9	3	37.4	448	2	216	5319
HA	94	F	50	DS	0	1	32.6	329	2	27	5714
HA	94	F	50	DS	0	2	49.8	310	1		5751
HA	94	F	50	DS	0	3	23.5	362	1		4307
HA	94	F	50	TK	1	1	32.3	325	1		5803
HA	94	F	50	TK	1	2	39.4	466	2	115	7002
HA	94	F	50	TK	1	3	30.8	293	1		4838
HA	94	F	50	TK	3	1	33.0	390	2	78	6633
HA	94	F	50	TK	3	2	33.8	380	2	77	6197
HA	94	F	50	TK	3	3	35.8	421	1		7468
HA	94	F	50	TK	9	1	42.5	432	2	161	8519
HA	94	F	50	TK	9	2	33.5	414	3	96	8389
HA	94	F	50	TK	9	3	42.6	466	4	67	10026
HA	94	F	50	TN	1	1	26.9	281	1		3546
HA	94	F	50	TN	1	2	44.6	305	3	86	6445
HA	94	F	50	TN	1	3	28.2	324	2	105	4643
HA	94	F	50	TN	3	1	31.0	507	3	174	6056
HA	94	F	50	TN	3	2	23.0	595	2	164	4952
HA	94	F	50	TN	3	3	28.3	293	1		5328
HA	94	F	50	TN	9	1	34.6	488	2	247	6735
HA	94	F	50	TN	9	2	31.6	337	1		5278
HA	94	F	50	TN	9	3	32.0	401	1		6963
HA	95	F	50	DS	0	1	22.9	299	2	87	3627
HA	95	F	50	DS	0	2	17.1	119	1		1287
HA	95	F	50	DS	0	3	11.8	104	1		907
HA	95	F	50	TK	1	1	13.8	123	1		1071
HA	95	F	50	TK	1	2	14.9	165	1		1453
HA	95	F	50	TK	1	3	14.7	145	1		1225
HA	95	F	50	TK	3	1	24.7	179	1		2306
HA	95	F	50	TK	3	2	13.8	146	1		1321
HA	95	F	50	TK	3	3	17.3	198	1		1949
HA	95	F	50	TK	9	1	33.0	215	1		3585
HA	95	F	50	TK	9	2	33.8	193	1		3662
HA	95	F	50	TK	9	3	27.4	281	1		3359
HA	95	F	50	TN	1	1	10.6	249	1		1951
HA	95	F	50	TN	1	2	49.6	214	1		4809
HA	95	F	50	TN	1	3	45.8	244	1		4590
HA	95	F	50	TN	3	1	55.2	278	1		7814
HA	95	F	50	TN	3	2	51.8	341	1		8072
HA	95	F	50	TN	3	3	34.7	247	1		4506
HA	95	F	50	TN	9	1	40.6	564	2	79	7418
HA	95	F	50	TN	9	2	38.3	339	1		5241
HA	95	F	50	TN	9	3	16.8	301	1		2882

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	96	M	70	DS	0	1	23.4	162	1		1690
HA	96	M	70	DS	0	2	27.9	103	1		1655
HA	96	M	70	DS	0	3	12.4	130	1		1138
HA	96	M	70	TK	1	1	34.7	143	1		2286
HA	96	M	70	TK	1	2	29.9	95	1		1767
HA	96	M	70	TK	1	3	12.7	66	1		742
HA	96	M	70	TK	3	1	14.8	726	3	482	4823
HA	96	M	70	TK	3	2	15.6	692	3	332	4725
HA	96	M	70	TK	3	3	17.8	646	3	413	4309
HA	96	M	70	TK	9	1	21.5	95	1		1254
HA	96	M	70	TK	9	2	31.8	700	3	437	5393
HA	96	M	70	TK	9	3	15.4	103	1		1034
HA	96	M	70	TN	1	1	26.7	140	1		1757
HA	96	M	70	TN	1	2	37.8	581	3	411	4635
HA	96	M	70	TN	1	3	16.6	723	3	314	5182
HA	96	M	70	TN	3	1	26.6	552	2	409	4382
HA	96	M	70	TN	3	2	23.9	704	3	468	5743
HA	96	M	70	TN	3	3	15.0	650	3	274	3812
HA	96	M	70	TN	9	1	23.1	791	3	430	6680
HA	96	M	70	TN	9	2	22.0	675	3	443	6703
HA	96	M	70	TN	9	3	23.5	542	2	442	4594
HA	97	F	70	DS	0	1	45.6	277	2	147	4993
HA	97	F	70	DS	0	2	10.2	354	2	233	1762
HA	97	F	70	DS	0	3	18.0	88	1		1127
HA	97	F	70	TK	1	1	29.4	205	2	103	2525
HA	97	F	70	TK	1	2	13.2	692	2	476	4279
HA	97	F	70	TK	1	3	39.4	152	1		2834
HA	97	F	70	TK	3	1	19.9	424	3	170	3015
HA	97	F	70	TK	3	2	35.5	233	1		3409
HA	97	F	70	TK	3	3	67.9	256	2	110	6335
HA	97	F	70	TK	9	1	34.9	501	2	381	5602
HA	97	F	70	TK	9	2	66.0	274	1		8433
HA	97	F	70	TK	9	3	64.2	357	2	27	9403
HA	97	F	70	TN	1	1	46.6	359	3	204	8013
HA	97	F	70	TN	1	2	67.3	405	4	149	12556
HA	97	F	70	TN	1	3	61.0	396	4	176	10888
HA	97	F	70	TN	3	1	52.9	383	2	44	8284
HA	97	F	70	TN	3	2	45.2	394	1		7619
HA	97	F	70	TN	3	3	48.0	473	3	192	9562
HA	97	F	70	TN	9	1	49.5	565	5	98	13616
HA	97	F	70	TN	9	2	108.8	472	4	204	18071
HA	97	F	70	TN	9	3	51.6	457	4	142	11098
HA	98	F	40	DS	0	1	15.0	309	2	159	3033
HA	98	F	40	DS	0	2	31.8	476	2	213	7544
HA	98	F	40	DS	0	3	30.6	346	2	133	4616
HA	98	F	40	TK	1	1	25.2	346	3	120	3842
HA	98	F	40	TK	1	2	28.6	467	2	352	5430
HA	98	F	40	TK	1	3	21.4	423	2	319	4143
HA	98	F	40	TK	3	1	17.1	502	2	355	4253
HA	98	F	40	TK	3	2	25.5	514	2	288	4412
HA	98	F	40	TK	3	3	34.3	563	3	166	6311
HA	98	F	40	TK	9	1	35.2	567	2	468	4888
HA	98	F	40	TK	9	2	76.8	518	3	333	9557
HA	98	F	40	TK	9	3	23.6	607	3	253	6019
HA	98	F	40	TN	1	1	55.1	426	5	92	10464
HA	98	F	40	TN	1	2	52.7	413	5	94	10351
HA	98	F	40	TN	1	3	42.2	420	2	277	6713
HA	98	F	40	TN	3	1	65.6	459	5	74	14629
HA	98	F	40	TN	3	2	58.6	453	5	106	12379
HA	98	F	40	TN	3	3	59.8	475	2	25	10804
HA	98	F	40	TN	9	1	54.6	547	4	124	15016
HA	98	F	40	TN	9	2	65.4	546	5	113	17707
HA	98	F	40	TN	9	3	83.4	571	4	91	19619
HA	99	F	40	DS	0	1	10.6	156	1		1287
HA	99	F	40	DS	0	2	11.0	106	1		757
HA	99	F	40	DS	0	3	26.8	189	1		2171
HA	99	F	40	TK	1	1	7.4	176	1		1120
HA	99	F	40	TK	1	2	10.0	491	3	186	3149
HA	99	F	40	TK	1	3	17.9	481	3	195	3544
HA	99	F	40	TK	3	1	15.5	325	2	223	2580
HA	99	F	40	TK	3	2	9.3	456	3	220	2788
HA	99	F	40	TK	3	3	9.3	465	2	338	2617
HA	99	F	40	TK	9	1	16.7	421	1		3218
HA	99	F	40	TK	9	2	16.4	668	2	223	4965
HA	99	F	40	TK	9	3	17.4	479	2	208	3713
HA	99	F	40	TN	1	1	15.8	564	3	204	5133
HA	99	F	40	TN	1	2	35.5	528	3	348	8445
HA	99	F	40	TN	1	3	44.6	460	3	170	8260
HA	99	F	40	TN	3	1	80.4	571	4	213	14319
HA	99	F	40	TN	3	2	30.8	492	3	266	6982
HA	99	F	40	TN	3	3	38.2	626	2	357	8174
HA	99	F	40	TN	9	1	50.2	592	2	186	10627
HA	99	F	40	TN	9	2	32.2	418	2	208	5974
HA	99	F	40	TN	9	3	32.5	583	3	304	6161
HA	100	F	30	DS	0	1	19.8	279	1		3383
HA	100	F	30	DS	0	2	11.6	301	1		2363
HA	100	F	30	DS	0	3	21.2	269	1		2936
HA	100	F	30	TK	1	1	12.6	231	1		2068
HA	100	F	30	TK	1	2	17.0	280	1		3189
HA	100	F	30	TK	1	3	18.4	248	2	105	2302
HA	100	F	30	TK	3	1	14.4	385	2	155	3745
HA	100	F	30	TK	3	2	19.7	324	2	104	3712
HA	100	F	30	TK	3	3	20.4	416	1		4435
HA	100	F	30	TK	9	1	31.6	384	2	133	6948
HA	100	F	30	TK	9	2	37.4	390	2	130	6890
HA	100	F	30	TK	9	3	32.2	364	3	141	6504
HA	100	F	30	TN	1	1	23.8	354	3	122	3797
HA	100	F	30	TN	1	2	20.2	355	2	132	4213
HA	100	F	30	TN	1	3	29.9	370	2	164	5610
HA	100	F	30	TN	3	1	25.0	432	2	128	4292
HA	100	F	30	TN	3	2	18.2	484	1		4674
HA	100	F	30	TN	3	3	15.9	479	2	165	4321
HA	100	F	30	TN	9	1	20.6	429	1		4189
HA	100	F	30	TN	9	2	30.9	425	3	124	6503
HA	100	F	30	TN	9	3	19.4	403	2	115	5017

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	101	M	50	DS	0	1	29.8	120	1		1957
HA	101	M	50	DS	0	2	10.2	169	1		1043
HA	101	M	50	DS	0	3	11.0	139	1		745
HA	101	M	50	TK	1	1	9.3	75	1		586
HA	101	M	50	TK	1	2	8.2	822	2	657	4669
HA	101	M	50	TK	1	3	10.9	204	1		1525
HA	101	M	50	TK	3	1	8.0	119	1		472
HA	101	M	50	TK	3	2	8.2	864	3	446	4651
HA	101	M	50	TK	3	3	11.3	773	2	612	3821
HA	101	M	50	TK	9	1	30.1	136	1		1939
HA	101	M	50	TK	9	2	11.8	358	1		2485
HA	101	M	50	TK	9	3	13.7	441	2	210	2304
HA	101	M	50	TN	1	1	10.1	407	3	142	2176
HA	101	M	50	TN	1	2	14.6	1092	2	974	5551
HA	101	M	50	TN	1	3	16.2	140	1		1356
HA	101	M	50	TN	3	1	14.5	237	1		1929
HA	101	M	50	TN	3	2	8.8	247	1		1505
HA	101	M	50	TN	3	3	12.6	147	1		1089
HA	101	M	50	TN	9	1	29.8	191	1		2627
HA	101	M	50	TN	9	2	24.4	185	1		2126
HA	101	M	50	TN	9	3	32.6	153	1		2551
HA	102	M	50	DS	0	1	18.6	433	2	229	4226
HA	102	M	50	DS	0	2	15.3	299	1		1744
HA	102	M	50	DS	0	3	15.4	311	1		2683
HA	102	M	50	TK	1	1	7.3	263	2	135	882
HA	102	M	50	TK	1	2	12.1	347	2	175	2471
HA	102	M	50	TK	1	3	17.0	288	1		2179
HA	102	M	50	TK	3	1	15.7	370	1		2664
HA	102	M	50	TK	3	2	20.1	176	1		1822
HA	102	M	50	TK	3	3	12.6	158	1		1124
HA	102	M	50	TK	9	1	26.6	310	1		3965
HA	102	M	50	TK	9	2	19.4	341	1		3018
HA	102	M	50	TK	9	3	25.5	612	1		6392
HA	102	M	50	TN	1	1	23.4	483	1		4637
HA	102	M	50	TN	1	2	19.4	266	1		2639
HA	102	M	50	TN	1	3	18.5	166	1		1727
HA	102	M	50	TN	3	1	34.2	368	1		4547
HA	102	M	50	TN	3	2	20.3	345	1		3941
HA	102	M	50	TN	3	3	31.9	388	1		4772
HA	102	M	50	TN	9	1	25.3	454	2	149	6248
HA	102	M	50	TN	9	2	30.9	375	1		3711
HA	102	M	50	TN	9	3	15.9	378	2	124	3692
HA	103	M	50	DS	0	1	11.9	192	1		1420
HA	103	M	50	DS	0	2	10.1	101	1		782
HA	103	M	50	DS	0	3	12.2	771	2	650	3966
HA	103	M	50	TK	1	1	16.2	769	2	591	5175
HA	103	M	50	TK	1	2	18.0	650	2	512	4826
HA	103	M	50	TK	1	3	26.4	263	1		2312
HA	103	M	50	TK	3	1	21.1	195	1		1397
HA	103	M	50	TK	3	2	10.0	736	2	579	3224
HA	103	M	50	TK	3	3	13.1	296	2	180	1409
HA	103	M	50	TK	9	1	13.8	238	2	113	1742
HA	103	M	50	TK	9	2	8.1	135	1		563
HA	103	M	50	TK	9	3	9.2	712	2	584	2648
HA	103	M	50	TN	1	1		718	2		3176
HA	103	M	50	TN	1	2	11.8	779	2	508	4734
HA	103	M	50	TN	1	3	9.8	154	1		1157
HA	103	M	50	TN	3	1	26.3	731	2	520	5167
HA	103	M	50	TN	3	2	23.2	203	2	133	1713
HA	103	M	50	TN	3	3	11.6	152	1		802
HA	103	M	50	TN	9	1	18.7	870	3	382	5630
HA	103	M	50	TN	9	2	10.4	128	1		710
HA	103	M	50	TN	9	3	50.6	303	1		3261
HA	104	M	50	DS	0	1	6.4	228	2	109	1008
HA	104	M	50	DS	0	2	9.7	434	2	126	1985
HA	104	M	50	DS	0	3	11.7	300	1		1554
HA	104	M	50	TK	1	1	9.2	428	2	217	1881
HA	104	M	50	TK	1	2	10.1	367	2	189	1864
HA	104	M	50	TK	1	3	7.1	364	2	196	1587
HA	104	M	50	TK	3	1	8.3	491	2	231	1851
HA	104	M	50	TK	3	2	6.7	164	1		704
HA	104	M	50	TK	3	3	6.5	130	1		553
HA	104	M	50	TK	9	1	12.3	875	2	672	3242
HA	104	M	50	TK	9	2	14.1	450	1		2341
HA	104	M	50	TK	9	3	8.5	441	2	282	2103
HA	104	M	50	TN	1	1	9.9	228	1		1233
HA	104	M	50	TN	1	2	6.7	252	1		1156
HA	104	M	50	TN	1	3	6.8	207	1		850
HA	104	M	50	TN	3	1	9.4	131	1		817
HA	104	M	50	TN	3	2	7.1	238	1		1152
HA	104	M	50	TN	3	3	10.0	378	2	183	1784
HA	104	M	50	TN	9	1	23.0	514	2	164	5466
HA	104	M	50	TN	9	2	18.2	398	2	114	3922
HA	104	M	50	TN	9	3	20.7	318	2	132	3141
HA	105	M	50	DS	0	1	8.3	764	2	636	2938
HA	105	M	50	DS	0	2	17.5	175	1		1322
HA	105	M	50	DS	0	3	8.3	302	2	240	1401
HA	105	M	50	TK	1	1	16.1	494	2	279	2386
HA	105	M	50	TK	1	2	20.0	218	1		1656
HA	105	M	50	TK	1	3	15.4	189	1		1511
HA	105	M	50	TK	3	1	38.1	235	2	70	4481
HA	105	M	50	TK	3	2	50.2	310	2	39	6308
HA	105	M	50	TK	3	3	35.9	217	2	56	4322
HA	105	M	50	TK	9	1	9.3	760	4	402	3293
HA	105	M	50	TK	9	2	13.4	552	2	330	2853
HA	105	M	50	TK	9	3	12.4	330	2	230	2169
HA	105	M	50	TN	1	1	6.8	240	1		907
HA	105	M	50	TN	1	2	7.3	534	2	272	2035
HA	105	M	50	TN	1	3	7.9	164	1		746
HA	105	M	50	TN	3	1	8.2	517	2	363	1766
HA	105	M	50	TN	3	2	15.0	263	1		1766
HA	105	M	50	TN	3	3	9.6	276	1		1290
HA	105	M	50	TN	9	1	8.9	340	2	128	1895
HA	105	M	50	TN	9	2	7.7	316	1		1787
HA	105	M	50	TN	9	3	7.6	162	1		780

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	106	F	70	DS	0	1	16.0	354	1		2035
HA	106	F	70	DS	0	2	13.9	454	2	274	2519
HA	106	F	70	DS	0	3	5.1	232	1		923
HA	106	F	70	TK	1	1	17.3	144	1		1337
HA	106	F	70	TK	1	2	6.6	120	1		544
HA	106	F	70	TK	1	3	11.6	172	1		1025
HA	106	F	70	TK	3	1	9.0	130	1		754
HA	106	F	70	TK	3	2	9.9	147	1		818
HA	106	F	70	TK	3	3	5.4	149	1		499
HA	106	F	70	TK	9	1	4.7	46	1		188
HA	106	F	70	TK	9	2	5.0	37	1		150
HA	106	F	70	TK	9	3	5.9	36	1		167
HA	106	F	70	TN	1	1	6.4	328	2	163	1075
HA	106	F	70	TN	1	2	10.6	344	2	152	1751
HA	106	F	70	TN	1	3	8.6	426	2	277	1500
HA	106	F	70	TN	3	1	8.6	147	1		705
HA	106	F	70	TN	3	2	10.7	114	1		757
HA	106	F	70	TN	3	3	5.9	230	1		858
HA	106	F	70	TN	9	1	18.6	143	1		1227
HA	106	F	70	TN	9	2	10.0	443	2	330	1619
HA	106	F	70	TN	9	3	7.9	177	1		740
HA	107	F	70	DS	0	1	35.4	637	2	361	5870
HA	107	F	70	DS	0	2	9.8	886	4	291	3885
HA	107	F	70	DS	0	3	7.0	161	1		682
HA	107	F	70	TK	1	1	16.0	518	4	160	3421
HA	107	F	70	TK	1	2	7.9	297	1		1591
HA	107	F	70	TK	1	3	18.6	279	1		2288
HA	107	F	70	TK	3	1	21.4	339	1		2502
HA	107	F	70	TK	3	2	20.8	355	1		2770
HA	107	F	70	TK	3	3	22.9	599	2	457	4250
HA	107	F	70	TK	9	1	22.2	331	2	116	3986
HA	107	F	70	TK	9	2	9.7	304	1		1718
HA	107	F	70	TK	9	3	17.3	300	1		2280
HA	107	F	70	TN	1	1	20.9	415	2	286	2945
HA	107	F	70	TN	1	2	33.2	461	2	266	5020
HA	107	F	70	TN	1	3	35.4	419	1		5168
HA	107	F	70	TN	3	1	40.6	424	1		5120
HA	107	F	70	TN	3	2	20.9	356	2	53	3329
HA	107	F	70	TN	3	3	26.2	299	2	103	3583
HA	107	F	70	TN	9	1	34.6	574	1		7137
HA	107	F	70	TN	9	2	27.2	482	2	71	5799
HA	107	F	70	TN	9	3	24.0	520	1		5619
HA	108	M	60	DS	0	1	5.4	136	1		538
HA	108	M	60	DS	0	2	8.2	485	2	326	1339
HA	108	M	60	DS	0	3	10.2	566	2	344	1652
HA	108	M	60	TK	1	1	6.4	705	2	574	2106
HA	108	M	60	TK	1	2	9.5	367	1		1692
HA	108	M	60	TK	1	3	8.1	256	2	103	1224
HA	108	M	60	TK	3	1	7.0	268	1		1138
HA	108	M	60	TK	3	2	5.2	112	1		358
HA	108	M	60	TK	3	3	5.1	153	1		463
HA	108	M	60	TK	9	1	7.2	364	1		1585
HA	108	M	60	TK	9	2	5.8	115	1		422
HA	108	M	60	TK	9	3	6.5	362	2	234	1332
HA	108	M	60	TN	1	1	9.1	556	2	409	2310
HA	108	M	60	TN	1	2	9.4	577	2	323	2295
HA	108	M	60	TN	1	3	7.0	157	1		667
HA	108	M	60	TN	3	1	14.1	163	1		1126
HA	108	M	60	TN	3	2	11.4	150	1		881
HA	108	M	60	TN	3	3	7.3	144	1		753
HA	108	M	60	TN	9	1	8.6	101	1		509
HA	108	M	60	TN	9	2	20.7	300	1		2201
HA	108	M	60	TN	9	3	7.4	266	2	119	921
HA	109	M	60	DS	0	1	5.8	314	2	156	1294
HA	109	M	60	DS	0	2	8.2	814	2	709	2786
HA	109	M	60	DS	0	3	6.8	173	1		756
HA	109	M	60	TK	1	1	7.4	105	1		413
HA	109	M	60	TK	1	2	5.5	998	2	698	3048
HA	109	M	60	TK	1	3	8.2	113	1		540
HA	109	M	60	TK	3	1	6.7	679	2	528	2118
HA	109	M	60	TK	3	2	5.0	813	2	679	2121
HA	109	M	60	TK	3	3	4.2	407	2	284	1099
HA	109	M	60	TK	9	1	9.1	392	2	184	1768
HA	109	M	60	TK	9	2	10.3	1106	2	962	4010
HA	109	M	60	TK	9	3	7.4	927	2	716	3267
HA	109	M	60	TN	1	1	11.4	945	3	420	3886
HA	109	M	60	TN	1	2	23.6	829	2	602	3940
HA	109	M	60	TN	1	3	14.1	817	2	678	3360
HA	109	M	60	TN	3	1	7.6	132	1		616
HA	109	M	60	TN	3	2	16.7	1094	2	882	4315
HA	109	M	60	TN	3	3	5.9	973	2	763	3401
HA	109	M	60	TN	9	1	9.8	1142	2	885	3852
HA	109	M	60	TN	9	2	10.2	639	2	168	3148
HA	109	M	60	TN	9	3	8.3	112	1		597
HA	110	M	50	DS	0	1	8.4	291	1		1426
HA	110	M	50	DS	0	2	7.7	520	2	379	1945
HA	110	M	50	DS	0	3	9.4	346	1		1650
HA	110	M	50	TK	1	1	9.0	305	1		1439
HA	110	M	50	TK	1	2	9.6	288	1		1655
HA	110	M	50	TK	1	3	8.6	230	1		1262
HA	110	M	50	TK	3	1	14.4	313	1		1858
HA	110	M	50	TK	3	2	10.2	290	1		1661
HA	110	M	50	TK	3	3	10.7	308	1		1786
HA	110	M	50	TK	9	1	9.3	429	1		2428
HA	110	M	50	TK	9	2	12.6	292	1		1730
HA	110	M	50	TK	9	3	8.1	182	1		1019
HA	110	M	50	TN	1	1	13.8	243	1		1582
HA	110	M	50	TN	1	2	16.0	354	1		2538
HA	110	M	50	TN	1	3	10.0	452	1		2255
HA	110	M	50	TN	3	1	9.5	239	1		1667
HA	110	M	50	TN	3	2	8.4	161	1		744
HA	110	M	50	TN	3	3	6.5	719	2	556	2801
HA	110	M	50	TN	9	1	12.1	409	1		2846
HA	110	M	50	TN	9	2	11.4	539	2	174	2403
HA	110	M	50	TN	9	3	9.9	236	1		1642

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	111	M	50	DS	0	1	5.2	97	1		401
HA	111	M	50	DS	0	2	5.4	95	1		380
HA	111	M	50	DS	0	3	5.2	93	1		355
HA	111	M	50	TK	1	1		210	2		576
HA	111	M	50	TK	1	2	6.2	148	1		555
HA	111	M	50	TK	1	3	7.0	119	1		518
HA	111	M	50	TK	3	1	7.0	128	1		543
HA	111	M	50	TK	3	2	10.6	195	1		998
HA	111	M	50	TK	3	3	7.3	181	2	59	945
HA	111	M	50	TK	9	1	12.9	256	1		1812
HA	111	M	50	TK	9	2		650	3		2720
HA	111	M	50	TK	9	3	20.9	343	2	123	2495
HA	111	M	50	TN	1	1	13.4	500	3	246	2900
HA	111	M	50	TN	1	2	10.6	179	1		960
HA	111	M	50	TN	1	3	7.9	488	2	391	2228
HA	111	M	50	TN	3	1	15.0	417	2	229	3469
HA	111	M	50	TN	3	2	32.0	588	3	198	4802
HA	111	M	50	TN	3	3	24.0	249	2	40	2902
HA	111	M	50	TN	9	1	26.1	649	3	358	6238
HA	111	M	50	TN	9	2	12.0	206	1		1220
HA	111	M	50	TN	9	3	34.4	685	2	431	6040
HA	112	M	60	DS	0	1	14.8	894	4	374	4004
HA	112	M	60	DS	0	2	12.5	316	2	221	1367
HA	112	M	60	DS	0	3	7.9	180	1		866
HA	112	M	60	TK	1	1	7.7	82	1		432
HA	112	M	60	TK	1	2	7.7	219	1		1039
HA	112	M	60	TK	1	3	6.9	686	2	531	2382
HA	112	M	60	TK	3	1	8.7	679	2	530	2589
HA	112	M	60	TK	3	2	11.0	929	2	637	3858
HA	112	M	60	TK	3	3	8.9	132	1		624
HA	112	M	60	TK	9	1	8.6	739	2	521	2380
HA	112	M	60	TK	9	2	11.8	764	2	591	3501
HA	112	M	60	TK	9	3	8.9	727	2	572	2185
HA	112	M	60	TN	1	1	10.6	987	2	794	3195
HA	112	M	60	TN	1	2	7.9	878	2	645	2817
HA	112	M	60	TN	1	3	6.8	122	1		438
HA	112	M	60	TN	3	1	20.2	1027	2	779	4216
HA	112	M	60	TN	3	2	13.2	116	1		859
HA	112	M	60	TN	3	3	8.6	145	1		842
HA	112	M	60	TN	9	1	10.4	813	2	643	3127
HA	112	M	60	TN	9	2	6.8	763	2	667	2858
HA	112	M	60	TN	9	3	8.9	1024	3	592	3663
HA	113	M	40	DS	0	1	14.8	403	1		2485
HA	113	M	40	DS	0	2	10.0	267	1		1392
HA	113	M	40	DS	0	3	13.6	380	1		2012
HA	113	M	40	TK	1	1	34.9	437	1		4608
HA	113	M	40	TK	1	2	77.5	499	5	55	12143
HA	113	M	40	TK	1	3	55.7	656	3	237	8179
HA	113	M	40	TK	3	1	53.5	337	2	70	7755
HA	113	M	40	TK	3	2	55.0	479	1		9237
HA	113	M	40	TK	3	3	54.2	432	3	124	7414
HA	113	M	40	TK	9	1	21.9	466	1		4506
HA	113	M	40	TK	9	2	36.4	303	2	102	5868
HA	113	M	40	TK	9	3	48.8	405	1		6395
HA	113	M	40	TN	1	1	13.0	459	1		3423
HA	113	M	40	TN	1	2	16.0	466	1		3063
HA	113	M	40	TN	1	3	19.1	395	1		2882
HA	113	M	40	TN	3	1	24.3	216	1		2549
HA	113	M	40	TN	3	2	19.4	499	3	176	4104
HA	113	M	40	TN	3	3	23.7	460	1		3467
HA	113	M	40	TN	9	1	38.9	329	1		5510
HA	113	M	40	TN	9	2	25.3	486	1		4016
HA	113	M	40	TN	9	3	25.5	410	1		4263
HA	114	F	40	DS	0	1	9.8	152	1		724
HA	114	F	40	DS	0	2	7.3	275	1		1164
HA	114	F	40	DS	0	3	8.5	718	2	617	2445
HA	114	F	40	TK	1	1	14.2	240	1		1542
HA	114	F	40	TK	1	2	11.4	618	2	512	1590
HA	114	F	40	TK	1	3	12.2	742	2	552	2537
HA	114	F	40	TK	3	1	16.6	801	2	533	3302
HA	114	F	40	TK	3	2	15.0	696	2	515	2535
HA	114	F	40	TK	3	3	10.9	788	2	546	2972
HA	114	F	40	TK	9	1	27.0	714	2	565	3502
HA	114	F	40	TK	9	2	15.7	690	2	507	2624
HA	114	F	40	TK	9	3	12.1	828	3	300	2616
HA	114	F	40	TN	1	1	25.3	664	2	410	5204
HA	114	F	40	TN	1	2	33.3	559	2	401	6116
HA	114	F	40	TN	1	3	28.9	1254	3	546	8133
HA	114	F	40	TN	3	1	21.8	544	2	320	4644
HA	114	F	40	TN	3	2	23.0	638	2	392	5125
HA	114	F	40	TN	3	3	38.6	1032	4	572	8231
HA	114	F	40	TN	9	1	20.2	413	3	106	3677
HA	114	F	40	TN	9	2	44.2	508	2	255	7177
HA	114	F	40	TN	9	3	36.6	571	2	171	5171
HA	115	M	40	DS	0	1	4.4	115	1		472
HA	115	M	40	DS	0	2	5.2	132	1		359
HA	115	M	40	DS	0	3	4.2	187	1		560
HA	115	M	40	TK	1	1	4.8	169	1		611
HA	115	M	40	TK	1	2	6.6	454	1		1712
HA	115	M	40	TK	1	3	6.7	176	1		827
HA	115	M	40	TK	3	1	6.8	194	1		936
HA	115	M	40	TK	3	2	5.1	374	2	145	1161
HA	115	M	40	TK	3	3	5.5	254	1		1054
HA	115	M	40	TK	9	1	10.3	387	2	138	2269
HA	115	M	40	TK	9	2	9.8	256	1		1477
HA	115	M	40	TK	9	3	12.6	179	1		1363
HA	115	M	40	TN	1	1	8.8	203	1		1095
HA	115	M	40	TN	1	2	8.8	284	1		1386
HA	115	M	40	TN	1	3	10.3	231	1		1221
HA	115	M	40	TN	3	1	5.9	140	1		582
HA	115	M	40	TN	3	2	8.8	300	1		1695
HA	115	M	40	TN	3	3	9.0	203	1		1129
HA	115	M	40	TN	9	1	10.6	357	1		2317
HA	115	M	40	TN	9	2	7.9	263	1		1281
HA	115	M	40	TN	9	3	12.3	235	1		1853

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
HA	116	M	40	DS	0	1	14.7	322	2	154	2604
HA	116	M	40	DS	0	2	13.9	224	1		1594
HA	116	M	40	DS	0	3	9.9	512	2	293	2504
HA	116	M	40	TK	1	1	8.1	319	1		1681
HA	116	M	40	TK	1	2	7.2	292	2	123	1213
HA	116	M	40	TK	1	3	8.0	146	1		717
HA	116	M	40	TK	3	1	19.8	372	1		3459
HA	116	M	40	TK	3	2	9.3	316	1		1722
HA	116	M	40	TK	3	3	19.8	350	1		2808
HA	116	M	40	TK	9	1	20.9	337	2	41	3495
HA	116	M	40	TK	9	2	29.2	322	2	129	4540
HA	116	M	40	TK	9	3	25.3	295	1		3429
HA	116	M	40	TN	1	1	14.2	331	2	178	2243
HA	116	M	40	TN	1	2	8.2	277	2	68	1714
HA	116	M	40	TN	1	3	17.0	192	1		1736
HA	116	M	40	TN	3	1	10.1	164	1		951
HA	116	M	40	TN	3	2	18.2	191	1		1692
HA	116	M	40	TN	3	3	13.4	214	2	76	1996
HA	116	M	40	TN	9	1	13.0	293	1		2081
HA	116	M	40	TN	9	2	13.8	217	1		1866
HA	116	M	40	TN	9	3	16.4	340	2	76	2844
HA	117	M	40	DS	0	1	9.4	261	2	150	1620
HA	117	M	40	DS	0	2	10.2	567	2	443	2045
HA	117	M	40	DS	0	3	8.6	405	2	194	1758
HA	117	M	40	TK	1	1	10.2	537	2	418	2074
HA	117	M	40	TK	1	2	6.1	533	3	295	1945
HA	117	M	40	TK	1	3	16.0	104	1		996
HA	117	M	40	TK	3	1	5.9	384	1		1427
HA	117	M	40	TK	3	2	7.8	247	1		1026
HA	117	M	40	TK	3	3	8.1	447	2	277	1773
HA	117	M	40	TK	9	1	9.8	186	1		1116
HA	117	M	40	TK	9	2	9.4	434	2	277	1730
HA	117	M	40	TK	9	3	7.0	421	2	287	1573
HA	117	M	40	TN	1	1	13.7	192	1		1547
HA	117	M	40	TN	1	2	12.5	166	1		1062
HA	117	M	40	TN	1	3	13.4	239	1		1463
HA	117	M	40	TN	3	1	15.8	281	2	144	2115
HA	117	M	40	TN	3	2	13.2	261	2	66	1820
HA	117	M	40	TN	3	3	48.8	214	1		4331
HA	117	M	40	TN	9	1	27.1	318	2	65	4143
HA	117	M	40	TN	9	2	19.6	370	3	105	4189
HA	117	M	40	TN	9	3	20.5	315	1		3158
HA	118	M	40	DS	0	1	9.4	236	1		1347
HA	118	M	40	DS	0	2	6.6	415	2	291	1631
HA	118	M	40	DS	0	3	5.4	386	2	241	1438
HA	118	M	40	TK	1	1	11.2	428	2	283	1957
HA	118	M	40	TK	1	2	9.0	151	1		727
HA	118	M	40	TK	1	3	10.6	180	1		1168
HA	118	M	40	TK	3	1	6.6	434	3	241	1514
HA	118	M	40	TK	3	2	11.0	366	2	183	1935
HA	118	M	40	TK	3	3	7.8	473	3	201	2148
HA	118	M	40	TK	9	1	5.8	445	3	232	1367
HA	118	M	40	TK	9	2	8.0	166	1		833
HA	118	M	40	TK	9	3	7.1	150	1		714
HA	118	M	40	TN	1	1		451	2		1138
HA	118	M	40	TN	1	2	12.6	246	1		1569
HA	118	M	40	TN	1	3	6.6	255	1		1180
HA	118	M	40	TN	3	1	5.8	458	2	335	1858
HA	118	M	40	TN	3	2	8.8	837	3	483	3146
HA	118	M	40	TN	3	3	11.8	264	1		1757
HA	118	M	40	TN	9	1	10.1	248	1		1401
HA	118	M	40	TN	9	2	10.9	257	1		1781
HA	118	M	40	TN	9	3	9.0	491	3	186	2322
HA	119	M	40	DS	0	1	7.7	124	1		626
HA	119	M	40	DS	0	2	10.7	117	1		640
HA	119	M	40	DS	0	3	5.9	143	1		465
HA	119	M	40	TK	1	1		390	2		1294
HA	119	M	40	TK	1	2	8.9	408	2	290	1009
HA	119	M	40	TK	1	3	9.8	408	2	297	1758
HA	119	M	40	TK	3	1	18.2	466	2	268	1999
HA	119	M	40	TK	3	2	11.2	268	1		1567
HA	119	M	40	TK	3	3	11.8	424	2	285	2079
HA	119	M	40	TK	9	1	7.6	528	2	249	2141
HA	119	M	40	TK	9	2	8.9	274	1		1473
HA	119	M	40	TK	9	3	7.5	307	1		1306
HA	119	M	40	TN	1	1	10.8	506	2	244	2456
HA	119	M	40	TN	1	2	9.0	547	2	269	2500
HA	119	M	40	TN	1	3	9.8	500	2	251	1389
HA	119	M	40	TN	3	1	12.1	443	1		2108
HA	119	M	40	TN	3	2	12.5	491	2	286	2832
HA	119	M	40	TN	3	3	10.9	562	2	450	2086
HA	119	M	40	TN	9	1	12.9	310	1		2536
HA	119	M	40	TN	9	2	13.4	209	1		1292
HA	119	M	40	TN	9	3	11.4	226	1		1621
HA	120	M	60	DS	0	1	13.4	615	2	441	2749
HA	120	M	60	DS	0	2	13.8	679	2	492	1662
HA	120	M	60	DS	0	3	10.0	691	3	484	2996
HA	120	M	60	TK	1	1	40.7	261	1		4649
HA	120	M	60	TK	1	2	12.1	645	2	463	1945
HA	120	M	60	TK	1	3	38.1	269	2	120	4300
HA	120	M	60	TK	3	1	14.7	204	1		1728
HA	120	M	60	TK	3	2	25.8	239	1		3202
HA	120	M	60	TK	3	3	29.5	332	2	145	4667
HA	120	M	60	TK	9	1	25.4	232	1		2838
HA	120	M	60	TK	9	2	24.0	244	1		3317
HA	120	M	60	TK	9	3	8.4	270	1		1621
HA	120	M	60	TN	1	1	23.0	603	4	260	4627
HA	120	M	60	TN	1	2	15.9	362	2	96	2558
HA	120	M	60	TN	1	3	12.1	548	2	333	1522
HA	120	M	60	TN	3	1	9.6	374	2	244	1749
HA	120	M	60	TN	3	2	18.6	722	3	471	4133
HA	120	M	60	TN	3	3	9.2	378	2	208	2065
HA	120	M	60	TN	9	1	17.7	466	2	104	4444
HA	120	M	60	TN	9	2	16.1	346	2	187	2398
HA	120	M	60	TN	9	3	13.5	407	2	129	3408

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
DP	1	M	60	DS	0	1	83.2	1162	5	629	9024
DP	1	M	60	DS	0	2	55.0	1030	3	590	8739
DP	1	M	60	DS	0	3	28.2	1051	5	585	6155
DP	1	M	60	TK	1	1	20.2	1164	4	822	5529
DP	1	M	60	TK	1	2	17.4	1280	5	788	4361
DP	1	M	60	TK	1	3	15.6	1155	4	816	3663
DP	1	M	60	TK	3	1	25.4	956	5	425	5458
DP	1	M	60	TK	3	2	29.9	1344	4	926	5691
DP	1	M	60	TK	3	3	24.1	1428	5	902	5068
DP	1	M	60	TN	1	1	33.5	1900	4	1153	8647
DP	1	M	60	TN	1	2	57.0	1091	5	631	10665
DP	1	M	60	TN	1	3	64.2	973	4	697	10111
DP	1	M	60	TN	3	1	68.0	1341	5	749	10887
DP	1	M	60	TN	3	2	40.1	967	4	632	9986
DP	1	M	60	TN	3	3	22.8	1104	4	619	4767
DP	2	F	70	DS	0	1	20.5	864	2	596	2073
DP	2	F	70	DS	0	2	9.1	781	2	599	1104
DP	2	F	70	DS	0	3	18.4	805	2	595	1737
DP	2	F	70	TK	1	1	8.8	1150	2	957	1390
DP	2	F	70	TK	1	2	6.2	1332	4	725	1240
DP	2	F	70	TK	1	3	32.4	288	1		2007
DP	2	F	70	TK	3	1	19.6	163	1		1035
DP	2	F	70	TK	3	2	8.2	1347	4	948	1583
DP	2	F	70	TK	3	3	23.6	537	3	215	1915
DP	2	F	70	TN	1	1	8.5	838	2	691	1127
DP	2	F	70	TN	1	2	6.2	887	3	503	770
DP	2	F	70	TN	1	3	18.6	937	2	734	1564
DP	2	F	70	TN	3	1	25.6	1241	3	690	2424
DP	2	F	70	TN	3	2	11.5	1153	3	773	1913
DP	2	F	70	TN	3	3	21.0	1189	2	886	2349
DP	3	M	60	DS	0	1	6.6	823	2	672	922
DP	3	M	60	DS	0	2	7.2	1061	2	633	987
DP	3	M	60	DS	0	3	5.9	844	2	662	864
DP	3	M	60	TK	1	1	3.3	865	2	696	499
DP	3	M	60	TK	1	2	3.6	916	3	535	949
DP	3	M	60	TK	1	3	3.8	1398	4	697	1137
DP	3	M	60	TK	3	1	21.0	1189	2	886	2349
DP	3	M	60	TK	3	2	3.8	1396	3	737	1027
DP	3	M	60	TK	3	3	5.4	1841	2	1695	1180
DP	3	M	60	TN	1	1	6.6	1768	5	738	2038
DP	3	M	60	TN	1	2	8.6	1355	3	698	1221
DP	3	M	60	TN	1	3	4.6	887	2	722	778
DP	3	M	60	TN	3	1	4.1	1109	4	591	1084
DP	3	M	60	TN	3	2	7.6	1275	4	581	1489
DP	3	M	60	TN	3	3	4.9	1065	3	754	1180
DP	4	M	50	DS	0	1	16.1	1224	4	552	2631
DP	4	M	50	DS	0	2	32.4	2042	3	1074	3520
DP	4	M	50	DS	0	3	17.3	1696	4	807	3524
DP	4	M	50	TK	1	1	10.1	1402	4	700	1804
DP	4	M	50	TK	1	2	17.2	1120	5	695	3480
DP	4	M	50	TK	1	3	48.6	1145	4	780	8034
DP	4	M	50	TK	3	1	34.6	1279	4	700	5742
DP	4	M	50	TK	3	2	20.9	1340	5	708	5044
DP	4	M	50	TK	3	3	22.7	1415	5	831	4244
DP	4	M	50	TN	1	1	35.2	1556	3	783	6941
DP	4	M	50	TN	1	2	8.6	2295	5	604	3244
DP	4	M	50	TN	1	3	18.8	2082	4	1025	3693
DP	4	M	50	TN	3	1	12.3	990	2	797	2391
DP	4	M	50	TN	3	2	17.1	1325	3	692	3327
DP	4	M	50	TN	3	3	23.7	1096	4	719	4381
DP	5	F	80	TK	1	1	2.4	533	3	193	569
DP	5	F	80	TK	1	2	1.9	518	3	282	542
DP	5	F	80	TK	1	3	3.6	73	1		190
DP	5	F	80	TK	3	1	6.1	562	1		750
DP	5	F	80	TK	3	2	4.9	7451	5	6066	3414
DP	5	F	80	TK	3	3	47.2	6059	4	4143	11824
DP	5	F	80	TN	1	1	2.3	606	3	288	683
DP	5	F	80	TN	1	2	2.2	662	3	270	621
DP	5	F	80	TN	1	3	1.9	737	3	259	632
DP	5	F	80	TN	3	1	2.1	599	3	200	597
DP	5	F	80	TN	3	2	2.6	1096	2	219	881
DP	5	F	80	TN	3	3	4.3	250	1		298
DP	6	M	70	DS	0	1	21.4	857	2	597	2937
DP	6	M	70	DS	0	2	24.8	1210	3	584	3602
DP	6	M	70	DS	0	3	34.1	957	2	645	2986
DP	6	M	70	TK	1	1	19.7	1039	2	592	3187
DP	6	M	70	TK	1	2	15.4	1424	2	544	2945
DP	6	M	70	TK	1	3	17.0	817	2	550	2713
DP	6	M	70	TK	3	1	23.7	866	2	559	3304
DP	6	M	70	TK	3	2	28.7	874	3	542	4345
DP	6	M	70	TK	3	3	29.8	881	2	505	3738
DP	6	M	70	TN	1	1	33.7	871	2	554	3323
DP	6	M	70	TN	1	2	44.2	902	3	549	4278
DP	6	M	70	TN	1	3	32.3	1046	3	611	5651
DP	6	M	70	TN	3	1	36.1	884	3	628	4112
DP	6	M	70	TN	3	2	17.3	1009	2	549	3357
DP	6	M	70	TN	3	3	32.1	895	3	559	4826
DP	7	F	50	DS	0	1	11.2	1045	2	389	1634
DP	7	F	50	DS	0	2	7.8	852	2	382	1419
DP	7	F	50	DS	0	3	18.7	462	2	340	1542
DP	7	F	50	TK	1	1	14.2	727	2	225	2190
DP	7	F	50	TK	1	2	6.4	425	2	177	808
DP	7	F	50	TK	1	3	16.7	383	2	209	2143
DP	7	F	50	TK	3	1	13.1	882	2	182	1933
DP	7	F	50	TK	3	2	11.2	534	2	174	1882
DP	7	F	50	TK	3	3	11.7	1321	2	195	2112
DP	7	F	50	TN	1	1	5.6	494	3	203	861
DP	7	F	50	TN	1	2	19.5	624	3	267	2812
DP	7	F	50	TN	1	3	11.8	708	2	183	2355
DP	7	F	50	TN	3	1	12.3	677	3	229	3094
DP	7	F	50	TN	3	2	14.1	536	2	196	2496
DP	7	F	50	TN	3	3	23.3	1116	2	255	3792

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
DP	8	F	30	DS	0	1	4.2	442	2	328	800
DP	8	F	30	DS	0	2	6.6	513	2	383	1056
DP	8	F	30	DS	0	3	5.8	674	3	305	1001
DP	8	F	30	TK	1	1	32.2	612	2	361	3129
DP	8	F	30	TK	1	2	18.3	584	2	392	2311
DP	8	F	30	TK	1	3	19.8	584	2	372	2666
DP	8	F	30	TK	3	1	31.3	538	2	346	3568
DP	8	F	30	TK	3	2	51.3	561	3	333	6687
DP	8	F	30	TK	3	3	11.3	3225	4	1643	6706
DP	8	F	31	TN	1	1	45.1	518	3	172	6963
DP	8	F	32	TN	1	2	39.1	475	2	327	8017
DP	8	F	33	TN	1	3	55.2	447	5	192	11630
DP	8	F	34	TN	3	1	96.4	592	4	267	12822
DP	8	F	35	TN	3	2	100.1	525	3	212	16633
DP	8	F	36	TN	3	3	94.2	584	2	320	13934
DP	9	F	80	DS	0	1	13.7	378	2	194	1130
DP	9	F	80	DS	0	2	10.7	982	2	754	1504
DP	9	F	80	DS	0	3	11.9	937	4	609	2153
DP	9	F	80	TK	1	1	8.3	1056	4	581	1767
DP	9	F	80	TK	1	2	7.1	904	3	565	1654
DP	9	F	80	TK	1	3	9.3	1062	4	639	2093
DP	9	F	80	TK	3	1	11.4	870	3	652	2131
DP	9	F	80	TK	3	2	9.5	913	3	685	1837
DP	9	F	80	TK	3	3	10.3	1017	3	738	1913
DP	9	F	80	TN	1	1	27.9	1082	5	532	4702
DP	9	F	80	TN	1	2	19.7	861	2	628	2707
DP	9	F	80	TN	1	3	23.8	892	2	711	3462
DP	9	F	80	TN	3	1	15.9	1014	3	799	4057
DP	9	F	80	TN	3	2	13.9	996	5	665	3352
DP	9	F	80	TN	3	3	23.4	1019	3	760	4724
DP	10	M	70	TK	1	1	12.9	1009	5	348	2556
DP	10	M	70	TK	1	2	12.3	1715	5	677	4247
DP	10	M	70	TK	1	3	8.8	1064	4	402	2137
DP	10	M	70	TN	1	1	11.0	1380	5	422	3415
DP	10	M	70	TN	1	2	8.8	1583	3	1193	2100
DP	10	M	70	TN	1	3	12.4	318	1		1195
DP	11	M	80	DS	0	1	9.4	1510	4	746	3105
DP	11	M	80	DS	0	2	8.0	1500	4	613	2646
DP	11	M	80	DS	0	3	17.0	824	3	575	2361
DP	11	M	80	TK	1	1	16.5	1057	3	726	3205
DP	11	M	80	TK	1	2	21.9	1001	3	604	4800
DP	11	M	80	TK	1	3	44.8	893	2	618	5089
DP	11	M	80	TK	3	1	73.2	782	2	562	9814
DP	11	M	80	TK	3	2	62.7	1262	3	463	5955
DP	11	M	80	TK	3	3	129.7	989	3	610	9977
DP	11	M	80	TN	1	1	19.4	1095	3	803	4580
DP	11	M	80	TN	1	2	23.6	1082	2	739	3576
DP	11	M	80	TN	1	3	27.2	1258	3	707	4461
DP	11	M	80	TN	3	1	45.4	1529	4	777	11744
DP	11	M	80	TN	3	2	17.0	1191	3	683	4919
DP	11	M	80	TN	3	3	32.6	1236	3	771	7023
DP	12	M	60	DS	0	1	3.9	377	2	241	503
DP	12	M	60	DS	0	2	5.6	737	3	367	1324
DP	12	M	60	DS	0	3	3.0	211	1		253
DP	12	M	60	TK	1	1	6.8	551	2	263	685
DP	12	M	60	TK	1	2	7.1	2553	2	2414	2754
DP	12	M	60	TK	1	3	6.1	389	1		657
DP	12	M	60	TK	3	1	6.4	824	2	594	1104
DP	12	M	60	TK	3	2	9.8	1070	2	766	1718
DP	12	M	60	TK	3	3	5.4	2588	3	1879	2528
DP	12	M	60	TN	1	1	6.4	1619	3	899	1463
DP	12	M	60	TN	1	2	5.4	1477	3	852	1939
DP	12	M	60	TN	1	3	8.6	730	2	404	1754
DP	12	M	60	TN	3	1	6.7	968	3	515	1668
DP	12	M	60	TN	3	2	14.5	445	2	172	1562
DP	12	M	60	TN	3	3	8.9	1126	2	861	1515
DP	13	M	70	DS	0	1	10.1	967	2	699	2383
DP	13	M	70	DS	0	2	19.4	979	2	574	2417
DP	13	M	70	DS	0	3	27.5	1822	3	1410	3789
DP	13	M	70	TK	1	1	4.3	724	2	610	1114
DP	13	M	70	TK	1	2	8.4	1398	2	668	1609
DP	13	M	70	TK	1	3	8.5	258	1		649
DP	13	M	70	TK	3	1	4.2	789	2	623	1028
DP	13	M	70	TK	3	2	5.4	1072	3	648	1637
DP	13	M	70	TK	3	3	16.9	763	4	268	4544
DP	13	M	70	TN	1	1	5.7	807	2	603	1252
DP	13	M	70	TN	1	2	13.9	851	2	584	1702
DP	13	M	70	TN	1	3	11.5	1336	2	588	2399
DP	13	M	70	TN	3	1	15.4	1105	3	578	2855
DP	13	M	70	TN	3	2	10.6	983	3	599	2648
DP	13	M	70	TN	3	3	6.5	1144	3	617	1899
DP	14	M	60	DS	0	1	5.8	896	2	614	1366
DP	14	M	60	DS	0	2	18.6	325	1		1491
DP	14	M	60	DS	0	3	11.7	860	2	668	1838
DP	14	M	60	TK	1	1	7.7	989	2	699	1504
DP	14	M	60	TK	1	2	24.8	382	1		1634
DP	14	M	60	TK	1	3	11.7	949	3	541	1574
DP	14	M	60	TK	3	1	5.5	802	2	600	1288
DP	14	M	60	TK	3	2	12.3	912	4	482	2020
DP	14	M	60	TK	3	3	12.6	700	2	539	1656
DP	14	M	60	TN	1	1	9.1	958	3	458	2205
DP	14	M	60	TN	1	2	12.2	1055	3	506	2763
DP	14	M	60	TN	1	3	21.6	832	3	490	3880
DP	14	M	60	TN	3	1	29.1	949	3	600	4921
DP	14	M	60	TN	3	2	27.1	806	3	497	3450
DP	14	M	60	TN	3	3	18.1	882	2	530	2723

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
DP	15	F	70	DS	0	1	11.5	1369	4	974	3172
DP	15	F	70	DS	0	2	18.5	1143	2	893	3205
DP	15	F	70	DS	0	3	17.7	1346	3	1079	3187
DP	15	F	70	TK	1	1	69.3	1290	2	170	6554
DP	15	F	70	TK	1	2	50.7	455	2	216	4081
DP	15	F	70	TK	1	3	45.2	574	3	107	6919
DP	15	F	70	TK	3	1	36.8	1355	3	925	8087
DP	15	F	70	TK	3	2	53.1	1262	3	897	11752
DP	15	F	70	TK	3	3	92.7	1311	3	792	12489
DP	15	F	70	TN	1	1	97.3	877	3	402	11188
DP	15	F	70	TN	1	2	88.2	671	2	115	14481
DP	15	F	70	TN	1	3	57.7	671	2	29	9202
DP	15	F	70	TN	3	1	88.9	531	2	66	14716
DP	15	F	70	TN	3	2	120.7	515	3	38	19716
DP	15	F	70	TN	3	3	118.6	1039	3	843	18604
DP	16	M	50	DS	0	1	67.7	870	3	433	7010
DP	16	M	50	DS	0	2	58.7	748	3	378	5350
DP	16	M	50	DS	0	3	62.1	832	2	493	6139
DP	16	M	50	TK	1	1	40.5	771	3	400	3764
DP	16	M	50	TK	1	2	36.0	906	3	438	3817
DP	16	M	50	TK	1	3	36.2	801	4	441	4075
DP	16	M	50	TK	3	1	52.9	876	4	505	8670
DP	16	M	50	TK	3	2	33.4	837	4	477	7904
DP	16	M	50	TK	3	3	44.2	911	3	464	7490
DP	16	M	50	TN	1	1	36.2	825	3	363	5800
DP	16	M	50	TN	1	2	35.9	911	4	413	5673
DP	16	M	50	TN	1	3	37.2	1137	2	535	4527
DP	16	M	50	TN	3	1	29.5	1048	3	443	4568
DP	16	M	50	TN	3	2	41.0	861	3	496	5858
DP	16	M	50	TN	3	3	62.4	852	3	452	6412
DP	17	M	60	DS	0	1	5.5	1464	2	1252	1462
DP	17	M	60	DS	0	2	3.7	2552	3	1921	2271
DP	17	M	60	DS	0	3	6.7	2118	2	1900	2312
DP	17	M	60	TK	1	1	12.9	605	2	184	1326
DP	17	M	60	TK	1	2	2.2	287	1		334
DP	17	M	60	TK	1	3	4.2	1081	3	503	1017
DP	17	M	60	TK	3	1	3.7	998	3	678	1131
DP	17	M	60	TK	3	2	5.0	932	4	696	1692
DP	17	M	60	TK	3	3	7.5	756	3	516	1275
DP	17	M	60	TN	1	1	18.7	1773	3	1328	4884
DP	17	M	60	TN	1	2	9.1	1009	3	444	2568
DP	17	M	60	TN	1	3	9.0	1814	3	789	2735
DP	17	M	60	TN	3	1	12.5	488	1		2110
DP	17	M	60	TN	3	2	9.0	1693	5	1062	3316
DP	17	M	60	TN	3	3	11.1	1005	4	552	2902
DP	18	M	60	DS	0	1	26.6	959	2	743	2637
DP	18	M	60	DS	0	2	41.7	733	2	560	3646
DP	18	M	60	DS	0	3	32.3	788	2	647	2876
DP	18	M	60	TK	1	1	32.9	1012	2	867	4075
DP	18	M	60	TK	1	2	19.0	393	2	227	1780
DP	18	M	60	TK	1	3	32.4	1136	3	725	3114
DP	18	M	60	TK	3	1	25.2	985	3	582	3271
DP	18	M	60	TK	3	2	5.8	1035	3	697	1596
DP	18	M	60	TK	3	3	11.5	942	3	688	2402
DP	18	M	60	TN	1	1	12.4	1053	5	514	3449
DP	18	M	60	TN	1	2	4.7	997	3	527	1714
DP	18	M	60	TN	1	3	13.6	1026	4	498	2974
DP	18	M	60	TN	3	1	14.2	950	3	630	3202
DP	18	M	60	TN	3	2	5.3	1319	4	774	1504
DP	18	M	60	TN	3	3	33.5	1017	5	590	4166
DP	19	M	70	DS	0	1	10.5	933	3	621	2123
DP	19	M	70	DS	0	2	17.6	1097	3	735	2275
DP	19	M	70	DS	0	3	13.8	1022	4	540	2262
DP	19	M	70	TK	1	1	26.5	882	3	558	2609
DP	19	M	70	TK	1	2	13.2	863	3	419	2567
DP	19	M	70	TK	1	3	17.5	832	2	684	2349
DP	19	M	70	TK	3	1	14.5	870	3	583	2168
DP	19	M	70	TK	3	2	14.0	822	3	600	1900
DP	19	M	70	TK	3	3	21.5	825	2	620	2248
DP	19	M	70	TN	1	1	10.5	1198	3	677	1990
DP	19	M	70	TN	1	2	17.6	1113	5	512	2854
DP	19	M	70	TN	1	3	6.6	962	3	699	1799
DP	19	M	70	TN	3	1	18.7	970	4	535	2517
DP	19	M	70	TN	3	2	23.5	934	3	552	2570
DP	19	M	70	TN	3	3	16.6	673	2	570	1650
DP	20	M	40	DS	0	1	4.2	320	1		504
DP	20	M	40	DS	0	2	4.5	973	2	509	1346
DP	20	M	40	DS	0	3	6.7	929	2	767	1412
DP	20	M	40	TK	1	1	3.5	784	2	588	833
DP	20	M	40	TK	1	2	2.5	734	3	520	867
DP	20	M	40	TK	1	3	2.0	796	2	551	625
DP	20	M	40	TK	3	1	5.6	1044	2	572	1298
DP	20	M	40	TK	3	2	4.2	1879	3	981	2501
DP	20	M	40	TK	3	3	5.8	917	3	561	1489
DP	20	M	40	TN	1	1	5.9	762	2	544	1040
DP	20	M	40	TN	1	2	6.0	928	3	530	1504
DP	20	M	40	TN	1	3	19.9	935	2	569	2277
DP	20	M	40	TN	3	1	12.9	2202	3	1393	3253
DP	20	M	40	TN	3	2	11.8	774	3	571	1978
DP	20	M	40	TN	3	3	10.9	2187	4	1334	3110
DP	21	M	60	DS	0	1	21.4	911	3	620	2605
DP	21	M	60	DS	0	2	19.7	308	3	118	2182
DP	21	M	60	DS	0	3	30.7	374	4	106	4729
DP	21	M	60	TK	1	1	30.9	256	2	48	2286
DP	21	M	60	TK	1	2	24.3	996	4	514	2452
DP	21	M	60	TK	1	3	14.8	816	3	469	1473
DP	21	M	60	TK	3	1	11.5	814	3	441	2006
DP	21	M	60	TK	3	2	27.2	231	2	116	1968
DP	21	M	60	TK	3	3	11.2	190	1		939
DP	21	M	60	TN	1	1	34.3	889	4	534	7223
DP	21	M	60	TN	1	2	72.1	841	4	606	8662
DP	21	M	60	TN	1	3	34.5	1116	4	664	5615
DP	21	M	60	TN	3	1	22.5	1006	4	735	4555
DP	21	M	60	TN	3	2	38.2	466	3	86	7121
DP	21	M	60	TN	3	3	27.6	1032	2	761	6587

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
DP	22	F	70	DS	0	1	25.4	961	3	650	3330
DP	22	F	70	DS	0	2	15.5	880	2	688	2776
DP	22	F	70	DS	0	3	19.3	881	3	508	4072
DP	22	F	70	TK	1	1	8.1	877	2	629	1658
DP	22	F	70	TK	1	2	11.2	2063	2	613	2634
DP	22	F	70	TK	1	3	21.6	969	2	623	2939
DP	22	F	70	TK	3	1	20.9	638	3	361	2105
DP	22	F	70	TK	3	2	18.5	2005	3	393	3489
DP	22	F	70	TK	3	3	19.6	853	3	403	4123
DP	22	F	70	TN	1	1	16.2	891	3	483	3015
DP	22	F	70	TN	1	2	10.8	1252	2	616	2147
DP	22	F	70	TN	1	3	12.4	892	2	677	2273
DP	22	F	70	TN	3	1	18.9	1201	5	323	4960
DP	22	F	70	TN	3	2	14.0	1148	4	464	4697
DP	22	F	70	TN	3	3	18.3	1181	4	514	3877
DP	23	M	60	DS	0	1	5.1	887	2	603	1183
DP	23	M	60	DS	0	2	7.3	779	2	536	1194
DP	23	M	60	DS	0	3	8.4	994	2	523	1264
DP	23	M	60	TK	1	1	11.8	696	2	400	1691
DP	23	M	60	TK	1	2	7.9	662	2	386	1258
DP	23	M	60	TK	1	3	6.1	1931	3	460	1765
DP	23	M	60	TK	3	1	8.3	1323	3	596	2235
DP	23	M	60	TK	3	2	9.2	1095	2	511	2178
DP	23	M	60	TK	3	3	10.7	935	4	417	2044
DP	23	M	60	TN	1	1	11.4	1055	2	451	2274
DP	23	M	60	TN	1	2	11.0	684	3	430	2430
DP	23	M	60	TN	1	3	11.0	684	3	430	2430
DP	23	M	60	TN	3	1	14.5	1223	5	668	4388
DP	23	M	60	TN	3	2	14.5	1223	5	668	4388
DP	23	M	60	TN	3	3	14.3	897	4	377	2999
DP	24	M	60	DS	0	1	8.0	2191	4	553	2863
DP	24	M	60	DS	0	2	7.9	818	3	467	1649
DP	24	M	60	DS	0	3	7.0	832	3	456	1699
DP	24	M	60	TK	1	1	16.1	876	3	510	2172
DP	24	M	60	TK	1	2	17.2	1070	2	497	2854
DP	24	M	60	TK	1	3	19.1	677	2	511	2365
DP	24	M	60	TK	3	1	16.7	1452	4	741	3437
DP	24	M	60	TK	3	2	28.6	1885	5	495	4677
DP	24	M	60	TK	3	3	26.9	960	4	471	3329
DP	24	M	60	TN	1	1	12.1	774	3	466	1805
DP	24	M	60	TN	1	2	14.2	1188	3	624	2194
DP	24	M	60	TN	1	3	11.3	985	2	502	1834
DP	24	M	60	TN	3	1	18.6	862	3	512	3935
DP	24	M	60	TN	3	2	24.1	874	2	510	3623
DP	24	M	60	TN	3	3	47.5	1587	4	510	7270
DP	25	M	60	DS	0	1	16.4	931	2	372	3874
DP	25	M	60	DS	0	2	19.4	858	4	405	5272
DP	25	M	60	DS	0	3	16.5	732	3	395	4261
DP	25	M	60	TK	1	1	25.5	2174	5	343	7831
DP	25	M	60	TK	1	2	29.6	2009	4	392	8134
DP	25	M	60	TK	1	3	32.5	834	4	364	7086
DP	25	M	60	TK	3	1	32.5	834	4	364	7086
DP	25	M	60	TK	3	2	40.5	911	3	449	9215
DP	25	M	60	TK	3	3	24.0	1465	5	355	7343
DP	25	M	60	TN	1	1	14.7	1017	4	416	3898
DP	25	M	60	TN	1	2	30.1	1099	5	331	6445
DP	25	M	60	TN	1	3	27.1	858	3	400	4915
DP	25	M	60	TN	3	1	31.3	1103	4	498	7189
DP	25	M	60	TN	3	2	33.9	938	5	293	8959
DP	25	M	60	TN	3	3	42.7	762	3	392	5777
DP	26	M	60	DS	0	1	37.9	870	3	406	4749
DP	26	M	60	DS	0	2	20.6	863	3	472	3889
DP	26	M	60	DS	0	3	19.2	828	2	539	3673
DP	26	M	60	TK	1	1	32.9	1119	3	500	4121
DP	26	M	60	TK	1	2	19.9	812	3	491	2941
DP	26	M	60	TK	1	3	12.8	846	2	523	2437
DP	26	M	60	TK	3	1	18.7	888	3	416	3161
DP	26	M	60	TK	3	2	18.7	689	3	425	2680
DP	26	M	60	TK	3	3	19.4	1127	3	448	3067
DP	26	M	60	TN	1	1	31.4	876	5	343	5495
DP	26	M	60	TN	1	2	15.1	1218	2	526	2969
DP	26	M	60	TN	1	3	10.0	1301	4	398	3071
DP	26	M	60	TN	3	1	12.2	1753	3	715	4734
DP	26	M	60	TN	3	2	12.6	1188	4	556	3919
DP	26	M	60	TN	3	3	11.2	1035	2	575	2742
DP	27	F	60	DS	0	1	13.3	1337	3	928	2647
DP	27	F	60	DS	0	2	40.1	1056	2	877	3865
DP	27	F	60	DS	0	3	46.9	950	3	811	4385
DP	27	F	60	TK	1	1	9.1	1069	2	882	1763
DP	27	F	60	TK	1	2	24.9	1229	4	664	2800
DP	27	F	60	TK	1	3	16.5	873	4	356	2720
DP	27	F	60	TK	3	1	6.6	1367	3	890	3160
DP	27	F	60	TK	3	2	74.6	1003	2	827	5905
DP	27	F	60	TK	3	3	33.1	817	4	260	4005
DP	27	F	60	TN	1	1	78.6	1128	4	782	9728
DP	27	F	60	TN	1	2	11.8	1236	2	1031	2451
DP	27	F	60	TN	1	3	11.8	1236	2	1031	2451
DP	27	F	60	TN	3	1	25.8	1838	5	1056	6269
DP	27	F	60	TN	3	2	22.6	1560	4	896	4702
DP	27	F	60	TN	3	3	24.9	1292	3	861	3464
DP	28	M	50	DS	0	1	8.9	486	2	337	1220
DP	28	M	50	DS	0	2	11.0	539	2	358	1594
DP	28	M	50	DS	0	3	15.4	799	4	374	2724
DP	28	M	50	TK	1	1	33.2	908	4	391	3459
DP	28	M	50	TK	1	2	20.2	767	4	433	2787
DP	28	M	50	TK	1	3	22.9	761	3	365	2318
DP	28	M	50	TK	3	1	42.9	795	2	460	4705
DP	28	M	50	TK	3	2	26.0	785	3	475	4177
DP	28	M	50	TK	3	3	32.2	756	3	454	3628
DP	28	M	50	TN	1	1	16.5	999	4	552	5629
DP	28	M	50	TN	1	2	26.0	1196	3	581	7103
DP	28	M	50	TN	1	3	20.4	996	3	555	5403
DP	28	M	50	TN	3	1	28.8	906	3	728	5827
DP	28	M	50	TN	3	2	20.6	1003	5	566	4190
DP	28	M	50	TN	3	3	14.0	1034	3	673	4938

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
DP	29	F	70	DS	0	1	4.4	196	1		341
DP	29	F	70	DS	0	2	1.5	189	1		200
DP	29	F	70	DS	0	3	1.0	113	1		102
DP	29	F	70	TK	1	1	3.1	784	2	672	807
DP	29	F	70	TK	1	2	4.2	789	4	422	1068
DP	29	F	70	TK	1	3	2.8	807	2	584	795
DP	29	F	70	TK	3	1	10.1	847	2	575	1569
DP	29	F	70	TK	3	2	3.1	837	3	538	1011
DP	29	F	70	TK	3	3	4.7	855	2	571	1144
DP	29	F	70	TN	1	1	3.1	829	3	625	780
DP	29	F	70	TN	1	2	2.2	984	2	697	929
DP	29	F	70	TN	1	3	3.2	873	2	769	821
DP	29	F	70	TN	3	1	5.5	1297	5	574	1765
DP	29	F	70	TN	3	2	3.8	1224	2	1019	1519
DP	29	F	70	TN	3	3	5.1	893	3	697	1496
DP	30	M	80	DS	0	1	20.9	702	3	328	2191
DP	30	M	80	DS	0	2	6.6	1447	4	441	2199
DP	30	M	80	DS	0	3	17.5	537	3	193	2529
DP	30	M	80	TK	1	1	12.9	1145	4	564	2192
DP	30	M	80	TK	1	2	8.3	999	2	771	1552
DP	30	M	80	TK	1	3	11.9	850	4	468	2107
DP	30	M	80	TK	3	1	9.5	1124	3	722	1568
DP	30	M	80	TK	3	2	11.3	1186	4	664	1877
DP	30	M	80	TK	3	3	11.6	1033	5	456	2027
DP	30	M	80	TN	1	1	29.1	903	3	656	3045
DP	30	M	80	TN	1	2	10.5	791	3	485	1442
DP	30	M	80	TN	1	3	12.3	516	3	281	1445
DP	30	M	80	TN	3	1	17.2	977	3	617	3569
DP	30	M	80	TN	3	2	16.4	865	3	386	3004
DP	30	M	80	TN	3	3	11.4	791	3	348	2177
DP	31	M	50	DS	0	1	28.8	201	2	88	2024
DP	31	M	50	DS	0	2	13.0	1490	3	888	2776
DP	31	M	50	DS	0	3	16.1	289	2	106	1454
DP	31	M	50	TK	1	1	25.7	825	3	454	2559
DP	31	M	50	TK	1	2	22.1	1412	3	1158	4342
DP	31	M	50	TK	1	3	21.6	1216	2	1083	4246
DP	31	M	50	TN	1	1	7.7	1112	4	364	2895
DP	31	M	50	TN	1	2	54.7	973	4	357	11538
DP	31	M	50	TN	1	3	10.8	1030	4	245	3082
DP	31	M	50	TN	3	1	10.2	1321	5	501	4097
DP	31	M	50	TN	3	2	19.8	892	2	759	2908
DP	31	M	50	TN	3	3	26.6	1059	3	690	3974
DP	32	M	50	DS	0	1	23.7	1145	2	922	2792
DP	32	M	50	DS	0	2	13.3	888	2	604	1438
DP	32	M	50	DS	0	3	14.9	693	2	433	1628
DP	32	M	50	TK	1	1	17.2	1007	4	587	2892
DP	32	M	50	TK	1	2	28.3	770	2	446	2569
DP	32	M	50	TK	1	3	14.1	1449	3	599	2656
DP	32	M	50	TK	3	1	66.1	925	2	561	5513
DP	32	M	50	TK	3	2	27.3	1061	3	453	3822
DP	32	M	50	TK	3	3	13.6	1094	3	437	2915
DP	32	M	50	TN	1	1	25.5	1190	3	552	3546
DP	32	M	50	TN	1	2	7.1	938	3	554	1716
DP	32	M	50	TN	1	3	18.4	1177	3	617	2724
DP	32	M	50	TN	3	1	28.2	1016	3	608	4189
DP	32	M	50	TN	3	2	10.2	730	2	477	2255
DP	32	M	50	TN	3	3	24.4	776	3	486	2997

Group	Subject	Gender	Age	Liquid type	Liquid volume	Trial	Highest peak amplitude	Duration time	# peaks	Longest peak-to-peak interval	Impulse
DP	33	M	50	DS	0	1	72.4	1282	4	709	9558
DP	33	M	50	DS	0	2	46.0	1028	4	742	8744
DP	33	M	50	DS	0	3	67.5	1833	5	518	10657
DP	33	M	50	TK	1	1	67.5	1833	5	518	10657
DP	33	M	50	TK	1	2	67.5	1833	5	518	10657
DP	33	M	50	TK	1	3	36.9	1079	4	363	7038
DP	33	M	50	TK	3	1	45.9	2212	4	788	9635
DP	33	M	50	TK	3	2	45.9	2212	4	788	9635
DP	33	M	50	TK	3	3	44.3	1367	5	798	8786
DP	33	M	50	TN	1	1	38.5	1153	5	631	8011
DP	33	M	50	TN	1	2	50.0	1155	4	711	6944
DP	33	M	50	TN	1	3	33.4	1144	4	583	6181
DP	33	M	50	TN	3	1	70.6	1162	5	423	7441
DP	33	M	50	TN	3	2	32.7	1485	5	573	7803
DP	33	M	50	TN	3	3	19.0	1127	4	673	5709
DP	34	M	60	DS	0	1	6.0	143	1		407
DP	34	M	60	DS	0	2	6.0	343	1		695
DP	34	M	60	DS	0	3	3.0	860	2	592	825
DP	34	M	60	TK	1	1	5.8	628	2	140	1247
DP	34	M	60	TK	1	2	9.6	588	2	149	1088
DP	34	M	60	TK	1	3	9.6	588	2	149	1088
DP	34	M	60	TK	3	1	9.6	588	2	149	1088
DP	34	M	60	TK	3	2	3.6	852	2	586	879
DP	34	M	60	TK	3	3	2.4	105	1		161
DP	34	M	60	TN	1	1	9.8	880	3	554	1725
DP	34	M	60	TN	1	2	4.4	1237	2	909	1981
DP	34	M	60	TN	1	3	10.4	253	1		885
DP	34	M	60	TN	3	1	4.9	572	1		1189
DP	34	M	60	TN	3	2	6.7	1285	2	974	2004
DP	34	M	60	TN	3	3	5.5	189	1		430
DP	35	F	80	DS	0	1	12.3	841	2	687	1581
DP	35	F	80	DS	0	2	16.5	825	3	508	1939
DP	35	F	80	DS	0	3	8.0	849	2	575	1123
DP	35	F	80	TK	1	1	14.5	1226	3	331	3290
DP	35	F	80	TK	1	2	25.0	789	3	325	4402
DP	35	F	80	TK	1	3	27.9	694	2	308	3748
DP	35	F	80	TK	3	1	31.5	1054	4	497	5148
DP	35	F	80	TK	3	2	39.3	1005	3	560	7377
DP	35	F	80	TK	3	3	24.0	1029	4	543	5061
DP	35	F	80	TN	1	1	9.3	778	3	388	2265
DP	35	F	80	TN	1	2	20.0	772	4	370	3697
DP	35	F	80	TN	1	3	8.4	1046	4	189	3275
DP	35	F	80	TN	3	1	12.8	2714	2	376	3933
DP	35	F	80	TN	3	2	17.4	745	3	246	4312
DP	35	F	80	TN	3	3	21.5	756	5	270	4732
DP	36	M	70	DS	0	1	34.1	929	3	590	4610
DP	36	M	70	DS	0	2	42.8	1081	4	691	5770
DP	36	M	70	DS	0	3	17.0	1328	2	285	3089
DP	36	M	70	TK	1	1	6.9	551	2	166	1114
DP	36	M	70	TK	1	2	37.2	1286	3	623	5181
DP	36	M	70	TK	1	3	29.1	934	2	634	4312
DP	36	M	70	TK	3	1	10.0	1150	2	774	2585
DP	36	M	70	TK	3	2	28.5	1028	4	602	4371
DP	36	M	70	TK	3	3	7.1	933	2	576	2287
DP	36	M	70	TN	1	1	24.2	1542	3	726	3973
DP	36	M	70	TN	1	2	13.0	949	3	567	2199
DP	36	M	70	TN	1	3	26.1	939	3	639	4012
DP	36	M	70	TN	3	1	23.2	1228	2	734	4944
DP	36	M	70	TN	3	2	25.7	1035	2	577	4610
DP	36	M	70	TN	3	3	22.6	996	4	350	4869