Drinking speed using a Pat Saunders valved straw TM, wide bore straw and a narrow bore straw in a normal adult population

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EVIDENCE UTILISATION

Abstract

Background

Straw drinking is often recommended as a strategy for managing swallowing difficulties in adult clinical populations. This study presents a range of normal adult straw drinking speeds and discusses clinical applications.

Method

Straw drinking speed in a normal healthy population of 70 adults aged from 18 years to 95 years of age was measured. Three types of straws were used: a Pat Saunders valved straw TM, a wide bore straw and a narrow bore straw. Participants drank 40 mls of water for each straw tested. All participants were asked to comment on the straws used. A mixed methods design was used where both quantitative and simple structured qualitative data were collected.

Results

Drinking speed was quickest for the wide bore straw, followed by the narrow bore straw and slowest for the Pat Saunders valved straw TM. This was supported by qualitative comments from the adults who reported that the Pat Saunders valved straw TM was the most difficult straw to use. There were no significant differences between straw flow or straw type and gender. There were significant changes with aging and a decrease in flow speed with the narrow bore straw. Weight and height had some effect on straw drinking speeds. There was a slight correlation between age and gender and age and height, but not between age and weight.

Conclusions

This paper presents data for a normal range of straw drinking speeds in a healthy adult population. It can be used in the assessment and monitoring of straw drinking in acquired disorders of swallowing.

Key words:

Equipment evaluation; normal data range ; straw drinking; assessment; progressive disorders

Background

Eating and drinking is a highly complex process that involves neuromuscular control and coordination, sensory perception, autonomic nervous system involvement, gastrointestinal functions and cardio-respiratory support (1; 2; 3). "Oropharyngeal Dysphagia" is a disorder that interrupts the effective process of feeding, eating and drinking at the oral preparatory phase, oral phase and pharyngeal phase (4). Dysphagia in adult populations have a range of aetiologies, that include : structural changes to oral and pharyngeal anatomy (e.g. following treatment for head and neck cancer); non-progressive neurological disorders (e.g. stroke, traumatic brain injury); and progressive neurological conditions (e.g. Parkinson's disease, motor neurone disease and multiple sclerosis(4).

Clinical practice in the assessment and management of dysphagia varies and is partially dependent on the experience of the clinician as well as the types of disorders treated (5; 6; 7). Some clinicians question why an oral motor examination is completed without any nutritional intake as neurological activation for both non nutritive and nutritive actions are distinct from each other (8; 9; 10; 11; 12; 13; 14). This paper evaluates the functional straw drinking skills of a normal adult population. It discusses the potential use of straw drinking as part of a basic nutritive assessment for the evaluation of swallowing difficulties in adult populations. It is based on a previous paediatric study, and discusses further issues related to using specialist equipment and the role of using normative data in assessment (15).

Drinking skills

When drinking, fluid is usually managed through sequential fluid bolus manipulation with minimal pausing (1;2;16;17). The natural pattern of breathing is different when drinking and people with no illnesses or disorders increase respiratory ventilation post sequential swallowing to compensate for the longer period of breath holding during swallowing (1;2;16). There are also more frequent episodes of inspiration in sequential swallowing compared to individual sips of fluid (16). When drinking from a straw, the tongue, pharyngeal and laryngeal structures move rapidly. The larynx raises and lowers and the epiglottis opens and closes during the swallow process (1; 17; 18). When the epiglottis closes there is a brief period of apnoea and this allows fluid to pass safely through into the pharynx. An extended period of apnoea occurs during laryngeal excursion when straw drinking (1).

Labial muscle activation is higher for straw drinking compared with cup drinking or taking liquid from a spoon (10;12;19). The labial activation for speech and for facial expression is lower than for straw drinking (19). When taking fluid from a cup, participants tend to take larger sips from a cup compared to a straw (17; 20). Sip size volumes for fluids decrease during sequential drinking but no specific changes in sip volumes occur with increases in age (participants were aged 60 -94 years old)(20).Daniels et al (18: 2004) measured straw drinking speeds across two groups;25 -35 year olds and 60 -83 year olds. They noted a change with aging with more frequent episodes of laryngeal penetration in older adults. Two distinct patterns of hyolaryngeal elevation occur during straw drinking (21). One pattern involves lowering of the hyolaryngeal complex with the epiglottis returning to an upright position between swallows. The other involves partially maintained hyolaryngeal elevation with epiglottic inversion between swallows. Whereas there are slight variations in the way normal healthy people swallow, both these swallow patterns are observed in younger and older participants, with no significant age effect. Height and gender have been found to influence sip sizes with taller people taking larger sips during cup drinking (21).In some studies, males take larger sips than females, (18; 20)., but when controlled for height gender difference with sip size is not significant (20). Verbal instructions to drink can also influence sip size amounts in comparison with people who are unaware that their drinking is being assessed (21).Participants who know they are being assessed take smaller sip sizes (mean = 6.6–6.8ml)compared to those who do not know the purpose of the assessment (mean = 16 ml)(21).

With children, speed and efficiency of straw use increase with maturity, although there are no reported differences between straw type, flow and gender (15 ; 23). Time taken to drink from a straw in typically developing children varies between these two studies, with children taking between 4 -63 seconds in the Hudspeth et al (23) study compared with 4.10 – 17.82 seconds (15). It is important to note that the bores of the straws were different with both studies, so direct comparisons need to be treated with caution (15;23).

Clinical applications

In some clinical contexts, straw use is encouraged as part of a muscle strengthening programme (10;11). The evidence for oral – motor muscle strengthening programmes is varied, but straw drinking is more likely to be useful as part of an oral – motor assessment (10;11). Using 3 oz of water using either a straw or cup for children (24), and across the lifespan (25) has been used to identify clients who are at risk of dysphagia. However, the straw use in these studies was optional and the use of this equipment was not the main focus of these studies. Using straws can be a useful indicator in evaluation of changes in bulbar function for children with myasthenia gravis (23). Children with this diagnosis show fluctuating speeds of fluid intake via a straw and take longer compared to typically developing children (23). As clients with progressive disorders can show change over time the use of normal ranges of straw drinking speeds can be an important and simple way to monitor change against normative data during assessment.

In clinical practice, it is rare for straw drinking to be included as part of an oromotor examination and basic bedside swallow assessment with adult clients. Indeed, a number of studies that have investigated the clinical practices of speech and language therapists/pathologists working in the clinical area of dysphagia, have not identified straw drinking as a usual part of dysphagia evaluation (5; 6; 7). Straw drinking could potentially be a useful inclusion in a basic dysphagia evaluation for a number of reasons. Asking a patient to attempt drinking through a straw could provide useful information about labial muscle strength in a functional context. It could also provide early information regarding the effectiveness of using a straw as part of the patient's dysphagia management.

Study Scope and Methods

This study evaluated a valved straw, the Pat Saunders™ valved straw (PSVS) on a normal adult population. It also collected data on narrow and wide bore straw speeds from the same population. This paper discusses the practical application of these data in the assessment of adults with swallowing difficulties.

Participants

Seventy adults between the ages of 18 and 95 were recruited from a student population at City University in London and via contacts within the student community outside of the university (Table 1 & Table 2). All participants were clearly informed of the study through written information approved by the Senate Research Committee of City University. Participants were also provided with the contact details of the researchers inviting them to ask any questions before taking part in the study, or during and post the study if they had any concerns. All participants signed a consent form once they had agreed to take part. None of the participants had any history indicative of neurological difficulties, and no participants had any swallowing disorders, congenital difficulties, any craniofacial surgical procedures or significant orthodontic work. Participants were excluded from the study if they reported any history of speech, respiratory, swallowing, or neurological problems, or oral, pharyngeal, or laryngeal structural abnormalities.

Equipment

The participants were asked to use three straws. These were a wide bore straw (length 20.3cm, width 0.8cm), a narrow bore straw (length 20.3cm, width 0.4cm) and a valved PSVS (length 25cm, width 0.6cm).

Procedure

Participants were seen individually. Three clear plastic disposable cups were placed in front of them, each with a different straw and 40ml of water inside. They were told to drink from the straws in any order, so that the order of straw presentation was the participant's choice alone.

This would also reduce any practice effects. For each participant, the researcher gave the same instructions:

'I want you to drink all of the water in one go. I will time this on a stopwatch… ready, steady, go.'

The participants drank 120ml of water in total ; they were asked to drink 40mls per straw .This was felt to be a suitable amount to gain enough information on sip size. They were asked to drink the water from each cup using a different straw and were timed with a stop watch as they drank. They were not told that the researchers were looking at differences in flow rates between the straws, and were therefore not informed of the different properties of the straws. They were then asked to give simple structured qualitative feedback on which straw they found hardest and easiest to use, whether they applied any particular technique to help them drink and any other information they felt was relevant.

A mixed methods design was used where both quantitative and simple structured qualitative data were collected. Quantitative data included straw speeds and qualitative data focused on which straws participants found the hardest and the easiest to drink from. It was hypothesized that the participants would drink from the wide straw the fastest as this was reported in a similar study with children (15). It was also hypothesized that men and taller participants would demonstrate the fastest drinking speeds. The PSVS has not been tested on a healthy population of adults, so it was unclear what effect it would have on their drinking abilities, though a previous study using PSVS straws with children showed that this took the longest to drink with (15). Straw speeds for men and women from 18 to 95 years of age were compared and correlations between drinking speed and height, weight and age were analyzed.

Results

Results from the sample were amalgamated into means and standard deviations for each of the straws used (Table 2). A Pearson correlation analysis evaluated differences between speed of flow for all straws and to evaluate any links between age, height, weight and speed. Analysis of variance (ANOVA) (SPSS package, 17.0, SPSS Inc., Chicago, IL, USA) was completed to explore any links between speed of flow across the age range. A Chi-square test analysed gender effects.

- *Table 1 here* –
- *Table 2 here*

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Speed of flow

Seventy healthy adult participants aged between 18 to 95 years displayed different mean times in seconds for each of the straws; i) PSVS mean = 13.82 seconds (SD 13.8199); ii) wide bore straw = 3.71 seconds (SD 1.58493) and iii) narrow bore straw = 4.03 seconds (SD 1.74607) (Table 3). Ranges of speeds for each of the straws are indicated in Table 3.

- *Put Table 3 about here -*

Age differences

The range of all drinking speeds are summarized in Table 4. ANOVA analysis showed a significant decrease in NBS drinking speed with older participants ; F (30, 70) = 2.828, $p < .002$. With both the PSVS (F (30, 70) = 1.516, $p > 0.120$), and the WBS (F (930, 70) = 0.353, $p > 0.999$) the differences were not significant, although a trend was noted for the WBS. Pearson's correlation analysis showed a high correlation between straw speed of drinking and age with the NBS, ($r = .561$, $n = 70$, $p = 0.5$), a medium correlation between straw speed of drinking and age with the WBS($r = .457$, $n = 70$, $p = 0.5$) and no correlation between straw speed of drinking and age with the PSVS($r = .457$, $n = 70$, $p = 0.5$).

- *Table 4 here-*

Weight ,height and age

Weights ranged from 45 kilograms to 102 kilograms. Heights ranged from 150 to 192 cms. The mean height of participants was 168.6 cms and the mean weight was 67 kilograms. The age range of participants was from 18 to 95 with a mean age of 38.51 years (Table 2). There was a high negative correlation between gender and height in that males were more likely to be taller ($r = -.53$, $n = 70$, $p = 0.5$). A high correlation was noted between height and weight, in that taller people were likely to weigh more ($r = .5$, $n = 70$, $p = 0.5$). With gender and weight there was a high correlation, with males tending to weigh more than females ($r = .52$, $n = 70$, $p = 0.5$). The tallest person presented with relatively fast speeds on the WBS & NBS, 2.6 and 2.56 seconds respectively (Participant 9). Participant 9's speed using the PSVS was 7.69, 6.2 seconds faster than the mean speed for this straw. The shortest person took 6.28 seconds to drink from the WBS and 5.78 seconds using the NBS (Participant 57). Participant 57 took 19.13 seconds to drink from the PSVS, 6 seconds slower than the mean score. The heaviest person was also one of the tallest (Participant 6). For this participant, scores of 2.78 seconds for the WBS and 2.69 seconds for the NBS were noted with 6. 60 seconds drinking time for the

PSVS .It is difficult to know whether to attribute fast speed using the straws to being tall or heavier and further samples are needed to clarify this.

A Pearson analysis showed that there was a small correlation between weight and the PSVS speeds ($r = .059$, $n = 70$, $p > 0.631$) and NBS straw drinking times and weight ($r = .135$, $n =70$, $p < 0.268$). A small negative correlation between weight and WBS speeds ($r = - .074$, $n = 70$, $p > 0.544$) was noted, i.e. participants who weighed less took longer to drink from this straw.

With height, there was a significant correlation between height and speed using the WBS ($r= - .275$ $p < 0.21$) and NBS($r= -.245$ $p < 0.41$) but not between height and the PSVS ($r =-.0.150$; $p = .216$).This suggests that the PSVS consistently slows the drinking speeds of participants regardless of variables such as height.

A small negative correlation was seen between age and gender ($r= -.141$, $p = .243$) and age and height ($r = -.212$; $p = .079$). There was a negligible correlation between age and weight, ($r = .169$; $p = .164$).

- *Put Table 5 about here -*

Gender effects

The participants consisted of 25 males and 45 females. Using a Chi square analysis, it was found that gender did not impact on drinking speeds with no levels of significance between gender and types of straws; PSVS (χ^2 (130, n = 70 = 134.877, p = .367; NBS, (χ^2 (116, n = 70 = 127.559, p = .218) and the WBS , (χ^2 (122, n = 70 = 133.414, p = .266)(Table 5).

Qualitative feedback

The qualitative data used a simple structured method which involved asking all participants the same questions. They all commented that they disliked using the PSVS and described it as being "effortful", "restricting" and "unhelpful for drinking". Some commented that '"t made me feel sick to suck so hard" or "it made me cough". Many people considered the mechanics of the straw; "the ball bearing was stopping the suck" and some described techniques: "If I stuck it to the side of my mouth it was easier". The slowest drinker from the PSVS (Participant 53) commented that it was "tough. I could feel my muscles working". The oldest participant in this study, participant 58 (95 years old) disliked the PSVS and found it hard to finish drinking the 40 ml of water. Although participant 58 found it difficult, she had a drinking speed of 48.47 seconds and was still faster than participant 53 (aged 22 years) who took 108 seconds.

Discussion

The results in this study with adults show some similarities with the child study (15) in that the PSVS demonstrated the slowest drinking speeds, the NBS was the second slowest to drink from and the WBS was the fastest for both adults and children to use (15). There was a higher correlation between drinking speed becoming slower with the NBS as participant age increased. With the PSVS or WBS there were no overall decreases with straw speed and age. However, it is recognized that only 11 participants in this study were aged over 70 years of age, and therefore a much larger sample is required for this age band. In the literature slower drinking tends to be associated with aging (18). However, participant 53 (a female, aged 22 years old) took 108 seconds to complete drinking 40mls of water using the PSVS. The mean speed for the PSVS was 13.82 seconds (range 2.36 seconds to 108 seconds). The speeds for the other two straws for this participant are not so discrepant in relation to the other participants; WBS = 4.32 seconds (mean = 3.72 seconds, range 1.47 – 8.12 seconds) and NBS = 4.44 seconds (mean = 4.03 seconds, range 1.57 – 9.97 seconds) . It was considered whether to exclude this participant from the data analysis. There is wide variety within the normal range of swallowing function and because of this it was decided to keep participant 53’s data in this study

(17). Potentially, the reasons why Participant 53 found the PSVS difficult could be to do with sensory issues. A larger sample of normal, healthy adults with more detailed qualitative analysis might help to identify why there is such wide variation.

The evidence for sip sizes of liquids from cups does show that men have larger sip sizes than women (20). Gender did not impact on either types of straws or straw speeds , and this was also the case with the paediatric population (15).This is another interesting point in that the evidence for sip sizes of liquids from cups does show that men do not have larger sip sizes than women if controlled for height (22). One suggestion is that perhaps gender differences are less obvious in straw drinking as straw bolus amounts tend to be smaller at around 15 mls, (smaller than cup sip amounts), and that sip volumes do tend to decrease with sequential drinking (22). Height and weight did have some impact on straw speeds, and this is similar to sip size studies (18; 22). However, as with aging, a larger normal sample may differentiate characteristics more clearly in terms of height and weight.

This study used just 40ml of water which was considered enough to assess sequential swallowing abilities. This has been an amount that has successfully yielded information on changes in sequential drinking patterns during a swallow assessment (23). It has also provided important information both in this study and in a study with children which can be applied to adult populations where change in swallow function is to be detected (15).This is important to consider when thinking about improving approaches to assessment for dysphagia as although it is known that the origin of nutritive and non nutritive activation are distinct from one another neurologically this distinction is not clearly differentiated in clinical practice (8; 9; 10; 11; 12; 13; 14).

The benefits of the PSVS as a clinical tool were also considered as a part of this study. Using a straw involves a higher recruitment of muscles than cup drinking (19). Therefore, using a PSVS is likely to have more of a fatiguing effect for an entire drink for clients which could be difficult for people with swallowing difficulties associated with disorders where muscle fatigue is a problem. There could potentially be benefits in using a valved straw for people where swallow function has changed in such a way that slowing down delivery of fluid via a straw would be helpful, but where oral muscle fatigue may not be a significant factor. For example, a person who has had a partial glossectomy for cancer of the tongue may find that slowing his /her rate of drinking reduces risk of airway penetration, but would not be subject to significant oral muscle fatigue. Conversely, a person with myasthenia gravis may find that the extra muscle function required to use a valved straw would result in faster muscle fatigue, which would counteract the benefits of using the device. It is recognized that the PSVS is important as fluid does not return down the straw and this may well counteract the fatigue effects. Further research to evaluate this would be useful.

The PSVS was found to take longer to suck than a normal straw and some participants reported that it was uncomfortable or effortful to use. The slower speed could be of benefit to a clinical population in that this would cause a slower rate of sequential swallowing. Because of the natural apnoea that occurs during sequential swallowing, slowing the pace can help develop a safer sequential swallow rhythm as well as allowing a regular means of re-oxygenation to occur (16). In addition, if a client with dysphagia uses a technique that slows their drinking speed and enables fluid to remain in the straw to minimize effort, it is possible that the risk of aspiration decreases as the muscles of the larynx and pharynx may have more time to coordinate effectively.

Using straws to assess and monitor drinking in acquired disorders of swallowing is simple to administer and low cost. There is wide variation in clinical assessment methods with a mixture of non-nutritive and nutritive tasks for clients (5; 6; 7). Using more specific tasks such as this one that evaluate some functional, nutritive activity is consistent with the idea that neurological activation of nutritive and non-nutritive skills is distinct (11; 12;

14). We recommend that more consistency in using simple nutritive assessments such as straw use can contribute to more useful assessment information for clients who have dysphagia. Clients can also monitor their own skills using the normative data as a reference point. Using straw drinking as part of assessment for dysphagia is important as the hyolaryngeal movement is different for sequential as opposed to single swallows, and therefore, and changes in sequential swallowing can be identified (17 ;20). Our study did involve giving verbal instructions to clients. Verbal commands can impact on sip size amounts (21). Further studies should also consider the impact that verbal commands have on a client's response when being assessed.

Conclusion

This study has recorded normative data on straw drinking with a sample of 70 adults. This data can be used in a clinical setting to assess sequential drinking. A test of straw drinking speed is simple and quick to administer alongside other observations of eating and drinking. Therefore, reference to a normative baseline can be useful in the assessment of adults with dysphagia. It would be beneficial to replicate this study with a range of specific neurological populations.

The authors recognize that further data from a normal population is likely to supplement the data already collected and may show some more specific individual differences in straw speeds both between genders and in relation to weight and height. It is also recommended that this type of data is used to discuss how practitioners in the field of dysphagia can improve and develop more effective and useful assessments of drinking skills.

Conflict of interests: None declared.

Ethics approval: Ethical approval was gained from City University, London, Ethics Committee.

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