Drinking speed using a valved Pat Saunders straw TM, wide bore straw and a narrow bore straw in school age children

EVIDENCE UTILISATION

Abstract

Background To understand the nature of straw drinking in relation to a group of children with specific eating and drinking difficulties it is first necessary to ascertain the range of normal function. Straw drinking is often recommended as a method that can support children with eating and drinking difficulties.

Method This study looked at straw drinking performance in a normal population of 125 children aged between 6 – 11 years of age. Three types of straws were used; a valved Pat Saunders straw TM, a wide bore straw and a narrow bore straw. Children drank 40 mls of water for each straw tested.

Results Children increased their speed of intake significantly for all straw types as they matured. Drinking speed was quickest for the wide bore straw followed by the narrow bore and slowest for the Pat Saunders straw. This was supported by qualitative feedback from the children with most finding the wide bore straw the easiest one to use and the valved Pat Saunders straw TM the hardest. There were significant differences in speed of flow between the Pat Saunders **TM** straw and wide bore straw, between the Pat Saunders **TM** straw and the narrow bore straw, and the wide bore straw and the narrow bore straw. There were no significant differences between straw flow or straw type and gender.

Conclusions This normative data for straw drinking in a paediatric population can be used to develop baseline measures for clinical assessment.

Key words: *straw drinking; normal data range; sequential drinking; equipment evaluation.*

Introduction

Drinking fluid using a straw is one method of maintaining hydration. It involves a complex interaction between the facial and tongue muscles to move liquid through the mouth into the pharynx and on into the oesophagus, (1). This paper evaluates the functional straw drinking skills of a normal population of children and discusses clinical applications of this data.

Drinking skills

During the process of eating and drinking the lip muscles provide stability for utensils used. In a small study of 11 women aged 18-25 years a higher level of labial muscle activation occurred when a straw was being used compared to the force required for speech or facial expression. Force was significantly more for fluid intake via a straw in comparison to when a spoon or cup was used, (1). Normal straw drinking involves a rapid, sequential movement of the pharyngeal hypolaryngeal structures. Partial laryngeal elevation occurs with the epiglottis inverted between swallows. After the swallow sequence is complete the larynx lowers and the epiglottis returns to an upright position. (2; 3; 4). Airway closure during the passage of the bolus through the pharynx results in brief apnea during the swallow. During straw drinking an extended duration of apnea when laryngeal excursion occurs during sequential swallowing, (2).

Daniels et al (3) examined straw drinking in 15 healthy males aged 30 +/- 3years. When taking fluid from a straw sequentially, the mean volume per swallow was 11.53 +/- 5.9ml (range 3.54 – 26.39 mls).In a further study of straw drinking in healthy young (25-35 years) and older adults (60-83 years) alterations in swallow physiology with ageing were noted (4). Laryngeal penetration was more frequent and was associated with changes in hypolaryngeal movement patterns in older adults.

Sips of fluid from a cup tend to be larger compared to straw sips, with cup sips being around 25mls average and straw sips around 15 mls, (5). Sip volume for both cups and straws decreases as the number of sequential sips increases (5). Lawless et al, (2003)(5) also found that cup drinking produced larger sip volumes compared to straw sips in normal adults, but no significant differentiation was noted in an older population (aged 60 – 94 years of age). Height and gender was also shown to have an impact on sip size, with males and taller people generally taking larger sip volumes (5). Interestingly, when the data was re-evaluated and participants were assessed on their height alone, the gender difference was not significant, (5).

Children's drinking skills

To date there have been few studies on sip size in paediatric populations. One study has looked at a group of children in a well child care setting between the age of 5 to 12 years and a group of children with non neuromuscular neurologic disease able to follow instructions. (6). Subjects were given 120mls of water from a straw (0.64cm diameter). Co-operation with the task was good and no adverse effects were noted. Results showed that the median time for well children aged between 5 – 6 years was 20 seconds, (range 11 – 55), and the median time for 11 – 12 year old was 5 seconds, (range 4 – 12). In comparison, 5 – 6 year old children from the neurology clinic had a median time of 22 seconds, (range 11 – 35); children from the same clinic aged 11-12 years had a median time of 16 seconds (range 5 – 63). This data demonstrates that in a normal population of children there is an increased speed and efficiency of straw drinking with age. The children with an underlying neurological diagnosis demonstrated slightly slower straw drinking speeds that became more marked with increasing age, (6).

Age, height and gender differences have been studied in the adult straw drinking literature but currently there is not any similar data available for straw drinking skills in a normally developing paediatric population. Straw drinking as an oral motor skill appears on developmental checklists from 12 months of age, (7). One small study has found that with cueing some infants aged between 8-12 months can be encouraged to drink from a straw (8).

Clinical applications

Straw drinking potentially has an application in relation to the assessment of functional oral motor and pharyngeal skills. Using 3 ounces of water taken using a straw or a cup without interruption has been used to determine which children are at risk of dysphagia, (9). Criteria for failing the test included coughing or choking during one minute after completion of the test, or an inability to complete the amount.

Muscle strengthening programmes to support skills such as straw drinking exists, (10), but the rationale underpinning oral motor intervention for training to increase the strength of the speech and swallowing musculature is variable, (11 ;12). Clarke (11) argues that there is still not enough normative data on the range of tone required to perform certain oral motor tasks for various muscle groups, therefore leading to the assumption that there still needs to be further research that can evaluate effectively the rationale underpinning interventions for muscle strengthening exercise. A systematic review of the effects of oral-motor exercises on swallowing by Arvedson et al (2010)(12) also describes similar issues; that the evidence underpinning oral motor treatment strategies and the benefits for developing swallowing function are presently not robust, (12).

Measures of functional straw use have been recognised clinically as potential indicators of bulbar muscle function to predict respiratory compromise and to support clinical decision making about medication use and hospital care. A "slurp test" has been devised and used to monitor bulbar muscle function in children who have congenital myasthenia, (6).Children with congenital myasthenia show fluctuating abilities to drink a measured amount of fluid with a straw according to their neurological status compared to normal peers, taking longer if muscle weakness is evident e.g. during illness, (6).

Background and rationale of the study

A piece of equipment that a Speech and Language Therapist may recommend for children and young people with difficulties drinking is a valved- straw. This is often suggested for use as children with impaired muscle tone may be unable to gain effective lip seal and intra-oral pressure needed to access fluid successfully from a normal straw. Poor maintenance of intra oral pressure may make straw drinking a more inefficient method of drinking. Use of a valved straw is considered to be more efficient than intake of fluid from a conventional straw. It has a one-way valve that allows fluid to stay within the straw even after pausing and removing the lips from the top of the straw. It may make drinking easier for those who need several sucks or attempts to bring the liquid all the way up the straw to the mouth. It may also reduce the effort required for fluid drinking, as fluid does not return down the straw mid drink.

Use of a valved-straw has not been formally evaluated on a normal population; therefore any accurate evaluation of an effect on function in a child who has been recommended specialist equipment such as this type of straw is isolated to single case study/intra-subject data.

The study aims to establish normative data for three different types of straws in a normal population of school age children to evaluate the differences in drinking speed and perceived ease of drinking. As well as providing a baseline of straw drinking speeds for children with normal oral motor skills, this data may be helpful in assessing the advantages and disadvantages of straws in comparison with other equipment to support the drinking skills of children with specific difficulties.

Method

Subjects

One hundred and twenty five pupils aged between 6 to 11 years of age were recruited from an inner city infant and junior primary school to participate in this study. Parents were informed of the study through clearly written information approved by an NHS ethics committee and were given the contact details of the researchers. Parents were invited to contact the researchers and ask questions before signing the consent form. The protocol for the study was approved by The City University Ethics Committee, and all participants parents gave signed consent before their child took part.

None of the participants had any history of neurological or swallowing impairment, a learning difficulty, any cranio-facial surgical procedures or significant orthodontic work.

Equipment

Three straws were used with the children. These were a wide bore straw (length 20.3 cm; width = 0.8cm), a narrow bore straw (length 20.3 cm; width = 0.4 cm) and a valved a valved Pat Saunders straw TM (length 25 cm; width = 0.6cm). All the straws were of the same colour.

Procedure

Children were seen in groups of four or five. Being seen in groups would be more conducive to enabling children to participate, and introduced an element of competition to enable the fastest drinking times. All children were shown the three straws by one of the researchers. Children were asked to choose which order to use the straws in, so that the order of straw presentation was the child's choice alone. This also would reduce any practice effects.

For each group of children, the researchers gave the following instructions:

"I want you to drink all the water up as fast as you can when you hear me say go……Then my colleague is going to record your time on a stop watch……OK, put the straw in your mouth…ready, steady…GO!"

Children had three cups of water. Each cup had 40mls in, so children drank 120 mls each in total. The amount, 120 mls is reported as being the standard specimen amount, (6). Children were asked to drink the water from each cup using a different straw. They were timed as they drank. They were not told that the researchers were looking for differences in flow rates between the straws and therefore were not aware of the different properties. They were then asked to give qualitative feedback about which straw they found the easiest; which straw they found most difficult, and were encouraged to add any other comments they wanted to make.

Data was analysed to assess the effect of different straws used. It was hypothesised that children would find the wide bore straw the fastest. The valved straw has not been tested in a group of healthy children so it was unclear what effect it would have on their drinking abilities. In addition, it was hypothesised that there would be a maturational effect, i.e. that younger children would take longer to drink from each of the straws, and there would be a noticeable change in straw drinking competence with older children. Finally, data would be analysed to assess any significant difference in straw use between girls and boys aged from 6 to 11 years of age.

Results

Results were amalgamated into means and standard deviations for each of the straws used (table 1).A Bonferroni analysis evaluated differences between speed of flow for all straws and a Pearson's correlation was performed to explore any links between age and speed. An ANOVA was performed using the SPSS package, 17.0 to evaluate differences between the straws in relation to speed of flow across the age range. A Chi-square test was performed to look at gender effects.

- *Put table 1 about here* –

Speed of flow

One hundred and twenty five children over an age range of 6-11 years demonstrated mean 40ml timed water test times of 6.97-17.82 seconds for a Pat Saunders valved straw TM, 4.10- 9.8 seconds for a wide bore straw and 4.83 -12 .11 seconds for a narrow bore straw. Interestingly, each of the maximum speed times for each of the straws was reported in the group of 6 year olds, (Table 2). Children took longer to drink from the Pat Saunders valved straw TM; in the middle was the narrow bore straw, with the wide bore straw being the fastest across all age groups. A Bonferroni analysis demonstrated a significant difference between the Pat Saunders valved straw TM and the wide bore straw across all ages , $p < 0.001$; and a significant difference between the Pat Saunders valved straw TM and the narrow bore straw, $p < 0.001$. There was also a significant difference between the wide bore and the narrow bore straws across the age range, $p > 0.025$.

Age differences

Analysis of the means and standard deviations for each age group and each straw revealed a maturational effect and an increase in speed of straw drinking for each of the age groups, (see Table 2). Younger children took longer to drink 40mls from all three straws compared to older children aged 10 and 11 years. Interestingly, the 10 year old group were slightly slower than their 9 year old peers but this was not a significant difference.

- *Put table 2 about here* –

Most variability in results was seen in the 6 year age group which may indicate that the skill is still being mastered at this age. ANOVA analysis demonstrated a significant difference in drinking speeds between each of the straws across the age range studies, ($F_{(2, 374)}$, 31.098, p = 0.001*). Looking at the results, the means and the standard deviations a maturational trend can be seen with age for all three types of straw, so that as the children increase with age, their competence with sucking and their rate of sucking sequentially increases. Pearson Correlation analysis demonstrated significant correlation between age and increase in speed for each of the straws;

Pat Saunders TM straw; r (123) = -.669; $p < 0.001$

Wide bore straw; r (123) = -.451; $p < 0.001$

Narrow bore straw; r (123)= -.616; $p < 0.001$

Gender effects

A comparison was carried out between straw type and gender for which there were no significant differences between type of straw and gender:

Pat Saunders TM straw; χ^2 (1, N = 125) = 0.392, p = 0.531

Wide bore straw; χ^2(1, N = 125) = 0.008, p = 0.929

Narrow bore straw; χ^2 (1, N = 125) = 0.008, p = 0.929

Qualititative feedback:

A number of children commented that the Pat Saunders valved straw TM was the most difficult. Comments about the Pat Saunders valved straw TM , most children rated as hardest included:

"There is something inside blocking the water".

"This is hard. It's because the water gets in and is blocked by the metal ball".

"……you had to keep swallowing it down".

"This was the hardest. It was too thick to drink with".

"This…..gives you more time to breathe".

The wide bore straw was judged as being the easiest straw to use. Comments about the wide bore straw, most children rated as easiest included:

"This is the fastest and the easiest one".

"This is the easiest cos it all goes fast".

"This one is the best for me and good".

Discussion

This straw data which has used a large sample of children will be of interest to clinicians as it provides data on what straw drinking speeds are within a normal population of 6-11 year olds. Normative age data for time taken to drink a standardised amount of fluid as provided by this study is a useful reference point which can enable clinicians to make judgements about a child's oral-motor functioning.

As the children matured in age, their competence with sequential straw drinking increased for all straws, thus a significant maturational trend was evident. These results are highly comparable with the Hudspeth et al, (6) study in that with normal children, there is an increased efficiency of straw drinking with age increase. Further study using a larger sample size with more equal numbers of children within each group would increase the validity of this data. In addition, a larger group study could focus on random allocation of children to specific order presentations of the straws for comparison.

Straw drinking as an oral motor skill appears on developmental checklists from 12 months of age, (8), although one small study has found that with cueing some infants between 8-12 months can be encouraged to drink from a straw (9). At six years of age there is the widest variability in time taken. It may be that at this age straw drinking is still an emerging oral motor skill. Evaluating straw drinking competence in younger populations may give further information on efficiency of this drinking technique.

There was a small difference noted with age as seen in Table 1. As children became older, they increased their speed of sequential straw drinking. Although this trend could be seen on looking at the means and standard deviations, the difference was not at a level of significance. Looking at an increased group size and a wider age range may further demonstrate age differences in straw drinking performance. Gender in relation to drinking and bolus amounts was mentioned in the literature but not evident in this study, (5). Again, an increased group size and a wider age range may further demonstrate differences in performance.

It is anticipated that this data may be particularly important for assessing a child's oral motor function. In particular it may be of clinical application when evaluating children who have had some change in oral motor function either through acquired or progressive changes. This has been demonstrated in populations affected by fluctuating neuromuscular ability (6) and may have application to other diagnostic groups to evaluate oral motor ability and any changes in function. Oral motor function is currently measured clinically with a range of subjective, un-standardised and observational measures. This study goes part way to supplying some normative objective measurement of one aspect of oral motor function.

Further study would be of interest to see if alterations from the age means for straw drinking correlate with any other measures of oral motor function such as range of movement, appearance of oral facial musculature and amount of drooling. Alongside observational assessments, a timed test of straw drinking may be able to give a useful measure for bulbar muscle function.

There was significant variability in straw drinking speeds between the different straws. The wide bore straw was reported as the easiest and was the quickest when compared to the narrow bore straw and valved straw. A narrow bore straw is the most commonly supplied straw on juice cartons and prescribed supplemental sip feeds. It may be that for some clinical situations where drinking is inefficient and reduced volumes of fluids are being consumed that recommending a wide bore straw could increase the speed and efficiency of drinking to maintain fluid intake. Some texts recommend use of the Pat Saunders valved straw TM for children who have a weak suck as the valve prevents liquid falling back down, (8), and straw drinking is recommended for children with congenital muscle disorders to help develop lip mobility, (13).

The Pat Saunders valved straw TM was the most difficult for the children. This was shown to be statistically significant, and was supported by the children's own judgements. Comments about the Pat

Saunders valved straw TM tended to focus on how the straw was constructed, with children attempting to verbally problem solve as to why the straw was more difficult for them. The Pat Saunders valved straw TM has been designed specifically for individuals who may have weak suction pressures to easily draw fluid up a straw and for those who may suffer from fatigue. The fluid not returning back down the straw between sips will save on sucking effort when drinking is resumed and may then lead to drinking skills being supported in individuals with these specific drinking issues. The Pat Saunders valved straw TM was of no benefit in enhancing speed of drinking in a group of unaffected children. However further evaluation would be useful in assessing any specific clinical benefit to drinking in children who have poor drinking ability relating to oral muscle weakness and fatigue.

While this is a relatively simple study it is the first normative data for straw drinking and forms some quantitative data with which to validate a measured volume test of straw drinking. This may then have application in measuring straw drinking function as part of oral motor evaluation in a range of clinical populations.

Conflict of interests, source of funding and authorship

The authors declare that they have no conflict of interests.

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The authors reviewed and contributed to the manuscript prior to submission for publication.

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Tables

Table 1: Data for means and standard deviations (in seconds) for the time taken to drink 40mls for each straw.

	Mean	**SD**
Valved Pat Saunders straw TM (40mls) n = 125	12.1146	5.99291
Wide bore straw (40mls) n = 125	6.9935	5.20055
Narrow bore straw (40mls) n = 125	8.7463	4.32546

Table 2: Data for means and standard deviations (in seconds) for the time taken to drink 40mls for each straw within each age band.

Age in years	**Valved Pat Saunders straw TM**		**Wide bore straw**		**Narrow bore straw**	
	mean	SD	mean	SD	mean	SD
6 (n = 40 ; 20 boys, 20 girls)	17.82	6.28	9.80	5.40	12.11	4.7
7 (n = 12 ; 7 boys, 5 girls)	11.60	5.10	8.17	4.6	9.62	3.0
8 (n = 16 ; 9 boys, 7 girls)	11.60	2.54	8.35	4.14	9.70	3.10
9 (n = 21 ; 11 boys, 10 girls)	7.90	1.40	4.10	1.7	6.11	2.8
10 (n = 26; 13 boys, 13 girls)	8.93	2.70	4.51	1.5	6.18	2.2
11 (n = 10 ; 4 boys, 6 girls)	6.97	1.98	4.40	0.76	4.83	0.83