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Matthew E. Falagas, Evridiki Vouloumanou, Eleni Plessa, George Peppas, Petros Rafailidis. Inaccuracies in dosing drugs with teaspoons-tablespoons. *International Journal of Clinical Practice*, 2010, 64 (9), pp.1185. 10.1111/j.1742-1241.2010.02402.x . hal-00555327

HAL Id: hal-00555327

<https://hal.science/hal-00555327>

Submitted on 13 Jan 2011

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|-------------------------------|---|
| Journal: | <i>International Journal of Clinical Practice</i> |
| Manuscript ID: | IJCP-12-09-0740 |
| Manuscript Type: | Short Report |
| Date Submitted by the Author: | 09-Dec-2009 |
| Complete List of Authors: | <p>Falagas, Matthew; Alfa Institute of Biomedical Sciences (AIBS), Athens, Greece, Department of Medicine, Tufts University School of Medicine, Boston, Massachusetts, USA.</p> <p>Vouloumanou, Evridiki; Alfa Institute of Biomedical Sciences (AIBS), Athens, Greece</p> <p>Plessa, Eleni; Alfa Institute of Biomedical Sciences (AIBS), Athens, Greece</p> <p>Peppas, George; Alfa Institute of Biomedical Sciences (AIBS), Athens, Greece</p> <p>Rafailidis, Petros; Alfa Institute of Biomedical Sciences (AIBS), Athens, Greece</p> |
| Specialty area: | |
| | |



Inaccuracies in dosing drugs with teaspoons-tablespoons

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Running head: Drug dosing with teaspoons/tablespoons
Funding: None
Conflict of interest: None
Word counts: abstract: 150, text: 1604
Number of Tables: 2
Number of references: 26

ABSTRACT

Background We aimed to evaluate the potential inaccuracies in administering the desired dose of drugs with teaspoons and tablespoons.

Methods We collected all the different teaspoons/tablespoons that were available in 25 households in the area of Attica, Greece and measured their volume capacity (ml).

Results A total of 71 teaspoons and 49 tablespoons were provided from the 25 female (mean age 48.0 years) study participants. When these utensils were filled with water, the volume capacity of the 71 teaspoons ranged from 2.5 to 7.3 ml; mean volume was 4.4 ml; median was 4.4 ml. When the standardized teaspoon was used, the volume ranged from 3.9 to 4.9 ml among the total of the 25 study participants. When a subset of 5 study participants filled this teaspoon with paracetamol syrup, mean volume was 4.8ml.

Conclusions Teaspoons and tablespoons are unreliable dosing devices and thus their use should no longer be recommended.

What's already known about this topic?

- Teaspoons and tablespoons, although convenient, are unreliable devices to measure and administer liquid medications
- This is of special importance for pediatric populations

What does this article add?

- Teaspoons and tablespoons appear to be unreliable devices when measuring and administering liquid medication is considered for pediatric populations.
- In addition, the performance of the study participants did not improve considerably when a teaspoon of a standardized volume capacity was used.
- The use of calibrated devices such as oral syringes is recommended for both measuring and administering liquid medication in order to prevent misdosing of liquid medications which may possibly result in suboptimal clinical effectiveness of the drug or raise safety concerns.

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Keywords: drug dosing, tablespoon, teaspoon

For Peer Review Only

INTRODUCTION

Teaspoons and tablespoons are available in almost every household. They are also commonly used as measuring and administering devices of liquid medication. Particularly, teaspoons are popular among parents and caregivers when measuring and administering liquid medication to children.^{1, 2}

Teaspoons' efficiency as measuring and administering devices has been questioned since the late 1970's.^{3, 4} As a result, other devices as medicine cups, oral droppers and oral syringes have been also used for measuring and administering medication to pediatric populations. However, studies have shown that parents and caregivers tend to use teaspoons instead of the above-mentioned devices.^{1, 2} Studies have also commented on the variability of the volume capacity of household teaspoons, implying that household teaspoons are inaccurate measuring and administering devices.^{1, 4, 5, 6} Thus either underdosing or overdosing may ensue, resulting in considerable consequences such as a reduction of the expected clinical efficacy, or more adverse events.⁷⁻¹⁰ In particular, regarding antibiotics, inaccuracy can result in emergence of resistant pathogens.^{11, 12}

Taking into consideration the available findings regarding the potential inaccuracy of household teaspoons in measuring and administering liquid medication, as well as our experience regarding the confusion of the parameter of a "teaspoonful" in our every day clinical practice we sought to evaluate the potential inaccuracies in administering liquid medication with teaspoons in a setting of 25 households in the area of Attica, Greece.

METHODS

We studied 25 households in Attica, Greece and asked 25 women of all ages to collect all the different teaspoons and tablespoons that were available in their households. The volume capacity (ml of water) of each teaspoon/tablespoon was measured with the use of calibrated syringes and recorded. One measurement was performed for each of the teaspoon/tablespoon. Two individual investigators (E.K.V and E.P) performed all the measurements. In addition, in order to evaluate the perception of a teaspoonful, a standardized teaspoon of a 5ml volume capacity from the package of a commercially

available in our country liquid medication was provided to the study participants and they were asked to fill this standardized device with water up to the level they assume it is full. This volume also was measured using calibrated syringes and was also recorded. The same procedure was followed for a subset of 5 study participants who were asked to fill the standardized teaspoon with paracetamol syrup that is commercially available in our country. An ethical approval for the conduction of this study was obtained from the ethics committee of the Alfa Institute of Biomedical Sciences.

RESULTS

Twenty-five women (mean age 48.0 years) participated in our study. Data regarding the age of the enrolled women, the number of different teaspoons and tablespoons measured, the volume capacity (in ml of water) for both teaspoons and tablespoons, as well as the perception of a teaspoonful (in ml of water) for each one of the study participants are tabulated and presented in Table 1. These 25 women provided a total of 71 teaspoons and 49 tablespoons. The volume capacity of the 71 measured teaspoons ranged from 2.5 to 7.3 ml. The mean volume was 4.4 ml; median was 4.4 ml. The volume capacity of the 49 measured tablespoons ranged from 6.7 to 13.4 ml. The mean volume was 10.4 ml; median was 10.3 ml. When the parameter “perception of a teaspoonful” was evaluated, the volume ranged from 3.9 to 4.9 ml of water among the total of the study participants. Mean volume was 4.4 ml of water; median was 4.4 ml of water. When the same parameter for the subset of 5 participants was evaluated, the volume was 4.8, 4.9, 4.8, 5.0, and 4.8 ml of syrup, respectively. Mean volume was 4.8 ml of syrup; median was 4.8 ml of syrup.

DISCUSSION

The main finding of our study is that considerable variability is observed regarding the volume capacity of both the measured teaspoons and tablespoons. Specifically, teaspoons’ volume capacity ranged from 2.5 to 7.3 ml, whereas tablespoons’ volume capacity ranged from 6.7 to 13.4 ml. In addition, when a standardized teaspoon of a 5ml volume capacity was provided, considerable heterogeneity among the study participants was observed regarding the perception of a teaspoonful, when they were asked to fill it with water.

Our findings are in accordance with the findings of other studies reporting considerable variability in the volume capacity of teaspoons and tablespoons. Specifically, in 4 studies, the volume capacity of the measured teaspoons ranged from 1.5 to 5ml,¹ 2.5 to 7.2ml,¹³ 3 to 7ml,¹⁴ and 2 to 9ml.¹⁵ respectively. Our findings regarding tablespoons were in accordance with another study that reported a volume capacity range of 7-14ml for the measured tablespoons.¹⁴

Dosing and administering medication to children is different in comparison to adults. Firstly, pediatric dosages need to be adjusted to age and body weight.^{1, 16, 17} As a result, pediatric populations are considered as more vulnerable to dosage errors.^{1, 9, 17-20} On the other hand, despite the fact that pediatricians try to calculate, and prescribe, the correct dosages for pediatric medication, the issues of measuring and administering medication, and especially liquid medication, to children is often underestimated or neglected. Teaspoons and tablespoons have been widely used for measuring and administering liquid medication to pediatric patients and they continue to be popular among parents and caregivers.^{1, 2} This might be explained by the fact that they are convenient to use. In addition, teaspoons and tablespoons are cheap and thus available to almost every household. More than one kind of different teaspoon/tablespoon is usually available in each household. Notably, in our study a total of 71 different teaspoons and 49 different tablespoons were available in the 25 households.

On the other hand, the fact that a parent/caregiver has a wide variety of teaspoons/tablespoons in different sizes, shapes, and consequently with different volume capacities, at his/her disposal when instructed to provide liquid medication to their children may result in inaccuracies during measuring and administering liquid medication with these devices.^{1, 3, 4, 6, 21} More so, parents and caregivers may be confused by the disparity observed in the information contained in package inserts; some of them advise against the use of teaspoon/tablespoon, whereas others suggest administration with these utensils. Teaspoons and tablespoons can also be easily pushed away and have the liquid medication spilled. This problem is probably bigger when liquid medication is provided to small children who may not stand still or cry. As a

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result, fear of spillage may prevent parents/caregivers from filling the teaspoons or tablespoons. Interestingly, a considerable number of participants in our study referred to this specific parameter as a suspensive factor during the procedure of filling the standardized teaspoon with water. On the other hand, this parameter may be less important when syrups or oral solutions are used instead of water. This may be because the above-mentioned liquid medications are more viscous compared to water. Notably, the measurements performed by the subset of study participants that was asked to fill the standardized teaspoon with syrup tended to be more accurate.

In addition to the above-mentioned parameters, literature provides worrying evidence of the consequences of misdosing, either overdosing or underdosing medication with the use of teaspoons. Specifically, a 5 year old girl who was given a prescription of albuterol syrup determined with the use of the term “1tsp” was reported to have albuterol toxicity because her stepfather used his everyday teaspoon to measure the syrup and gave her 50% more than the prescribed amount of albuterol with each dose.²² On the other hand, an antiepileptic treatment failure with ethosuximide has also been reported in a child whose parents used a mocha spoon that was available in their house in the absence of a standardized teaspoon in the packaging of the medication.²³ Similarly, misdosing of antibiotics due to the use of teaspoons and tablespoons may result in emergence of antimicrobial resistance.

In this regard, calibrated devices as dispensing cups, oral droppers, and oral syringes have also been recommended for measuring and administering liquid medication to children.⁴ Potential advantages of oral syringes, apart from the fact that they are calibrated, is that they eliminate the fear of spillage, and may possibly create an impression that the treatment is of greater importance and thus increase compliance.²⁴ In studies comparing the use of teaspoons with oral syringes, caregivers who used teaspoons demonstrated higher levels of inaccuracies in comparison with those who used oral syringes.^{25, 26}

Adult patients are also not exempt from misdosing issues related to the extreme variability of teaspoon and tablespoon volume capacity. A considerable number of

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4 medications is available in the form of syrups or elixirs for use in adults. Thus at least
5 theoretically, underdosing may lead to subtherapeutic (if any) effects while overdosing
6 can result in toxicity.
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11 Our study has several limitations that should be taken into consideration in the
12 interpretation of its findings. Firstly, the number of study participants is rather limited
13 and consists of females of all ages, including mothers and grandmothers that are
14 expected to be more familiar with the use of teaspoons compared to the enrolled
15 younger women. In addition, paracetamol syrup was used instead of an antibiotic
16 solution. The antibiotic solution might have provided useful information regarding the
17 ability of the study participants to prepare and administer the correct concentration with
18 the use of their household spoons.
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27 In conclusion, teaspoons and tablespoons appear to be unreliable devices when
28 measuring and administering liquid medication is considered, and especially to pediatric
29 populations. As the performance of the study participants did not improve considerably
30 when a teaspoon of a standardized volume capacity was used, the use of calibrated
31 devices such as oral syringes is recommended for both measuring and administering
32 liquid medication.
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Table 1. Data regarding the variation of volume capacity of the measured teaspoon/tablespoons and the heterogeneity regarding the perception of a “teaspoonful” among the study participants.

| Study participant | Age (years) | Number of tsp/household | Number of tbsp/household | Volume capacity (ml) of tsp/[range]* | Volume capacity (ml) of tbsp/[range]* | Perception of a “teaspoonful” (ml) |
|-------------------|-------------|-------------------------|--------------------------|--------------------------------------|---------------------------------------|------------------------------------|
| 1. | 24 | 3 | 1 | [3.8-4.8] | (11.0) | (4.3) |
| 2. | 25 | 6 | 5 | [2.5-7.2] | [8.8-13.1] | (4.6) |
| 3. | 62 | 3 | 1 | [4.8-7.2] | (11.0) | (4.3) |
| 4. | 25 | 2 | 2 | (3.6), (4.8) | (8.3), (10.0) | (4.8) |
| 5. | 33 | 4 | 2 | [4.3-5.3] | (8.8), (12.5) | (4.6) |
| 6. | 60 | 6 | 3 | [3.7-5.2] | [9.1-12.2] | (4.2) |
| 7. | 62 | 4 | 3 | [3.6-4.8] | [8.1-11.0] | (4.1) |
| 8. | 35 | 3 | 3 | [3.7-4.6] | [8.7-11.5] | (4.5) |
| 9. | 82 | 3 | 2 | [4.4-5.6] | (9.7), (12.3) | (3.9) |
| 10. | 29 | 3 | 3 | [3.8-5.1] | [8.3-11.4] | (4.4) |
| 11. | 59 | 4 | 3 | [3.6-4.1] | [8.7-12.6] | (4.3) |
| 12. | 64 | 3 | 3 | [2.9-3.6] | [8.8-12.9] | (4.1) |
| 13. | 84 | 2 | 2 | (3.5), (5.9) | (12.9), (13.4) | (4.0) |
| 14. | 47 | 4 | 1 | [4.7-7.3] | (10.3) | (4.7) |
| 15. | 53 | 2 | 1 | (4.0), (5.5) | (9.5) | (4.2) |
| 16. | 22 | 1 | 1 | (4.3) | (7.5) | (4.5) |
| 17. | 63 | 2 | 1 | (3.2), (4.8) | (7.8) | (4.9) |

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|-----|----|---|---|--------------|----------------|-------|
| 18. | 25 | 1 | 1 | (4.9) | (7.5) | (4.9) |
| 19. | 65 | 3 | 1 | [3.7-4.8] | (10.1) | (4.3) |
| 20. | 31 | 2 | 1 | (3.6), (4.4) | (12.9) | (4.8) |
| 21. | 57 | 2 | 3 | (3.3), (4.5) | [9.9-12.6] | (4.4) |
| 22. | 55 | 1 | 1 | (4.7) | (6.7) | (4.7) |
| 23. | 38 | 2 | 1 | (6.3), (4.6) | (10.7) | (4.5) |
| 24. | 72 | 3 | 2 | [4.4-5.9] | (12.5), (12.8) | (4.2) |
| 25. | 30 | 2 | 2 | (3.7), (4.9) | (9.7), (11.8) | (4.7) |

Abbreviations: tsp = teaspoons, tbsp = tablespoons.

* = Data in brackets refer to the volume range when more than 2 teaspoons/tablespoons were measured.

Table 2. Data regarding the volume variations (ml of water) of the evaluated teaspoons/tablespoons, and the variation in the perception of a teaspoonful/tablespoonful (ml of water, and ml of syrup).

| | Volume (ml of water) | | Perception of a teaspoonful (ml of water) [§] | Perception of a teaspoonful (ml of syrup) ^{§§} |
|--------------|-------------------------|------------|---|--|
| | tsp | tbsp | | |
| Mean | 4.4 | 10.4 | 4.4 | 4.8 |
| Median | 4.4 | 10.3 | 4.4 | 4.8 |
| Range | (2.5-7.3) | (6.7-13.4) | (3.9-4.9) | (4.8-5.0) |
| Total number | 71 | 49 | NA | NA |

Abbreviations: tsp = teaspoons, tbsp = tablespoons, NA = non-applicable.

§ = Data refer to the total of the 25 study participants.

§§ = Data refer to a subset of 5 study participants.