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ORIGINAL RESEARCH

Tablet-splitting: a common yet not so innocent practice

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Abstract

Aim. This paper is a report of a study conducted to quantify (i) the mean deviation from theoretical weight and (ii) the mean weight loss, after tablet-splitting with three different, commonly used splitting methods.

Background. Tablet-splitting is a widespread practice among all sectors of health care for different reasons: it increases dose flexibility, makes tablet parts easier to swallow and allows cost savings for both patients and healthcare providers. However, the tablet parts obtained are often not equal in size, and a substantial amount of tablet can be lost during splitting.

Method. Five volunteers were asked to mimic the situation in nursing homes and to split eight tablets of different sizes and shapes using three different routine methods: (i) with a splitting device (Pilomat®), (ii) with scissors for unscored tablets or manual splitting for scored tablets and (iii) with a kitchen knife. Before and after splitting, tablets and tablet parts were weighed using an analytical balance. The data were collected in 2007.

Results. For all tablets, method 1 gave a statistically significantly lower mean deviation from theoretical weight. The difference between method 2 and method 3 was not statistically significant. When pooling the different products, method 1 also induced significantly less weight loss than the two other methods.

Conclusion. Large dose deviations or weight losses can occur while splitting tablets. This could have serious clinical consequences for medications with a narrow therapeutic-toxic range. On the basis of the results in this report, we recommend use of a splitting device when splitting cannot be avoided.

Keywords: nursing, nursing homes, practice guideline, tablet-splitting, weight deviations

Introduction

Tablet-splitting is a widespread practice internationally in all sectors of health care. A study in primary care in Germany showed that 24·1% of all drugs were split (Quinzler *et al.* 2006). There are multiple reasons for this practice. First, splitting tablets improves dose flexibility, which is important when doses need to be adapted to the specific needs of certain patient populations (e.g. older adults, children) or when doses need to be thoroughly titrated (Fischbach *et al.* 2001). Second, it makes the different tablet parts easier to swallow. Finally, it could allow cost savings for both

patients and healthcare providers, because the use of flat rate charges for medications, independent of dose strength, is common (Biron *et al.* 1999, Van Santen *et al.* 2002, Polli *et al.* 2003).

In nursing homes, nurses are responsible for the administration of medication to residents, and consequently for splitting tablets. Medication errors, especially during the administration to residents, are an important concern in nursing homes (Handler *et al.* 2004, Hansen *et al.* 2006, Pierson *et al.* 2007). The most frequently reported types of errors are omissions, wrong doses, wrong techniques and unauthorised drug administration (Barker *et al.* 1982, 2002, Pierson *et al.* 2007, Gerber *et al.* 2008, Barber *et al.* 2009, Van Den Bemt *et al.* 2009). Inaccurate splitting constitutes both a wrong technique when it is performed without the correct device and a dosing error, and could potentially result in harm for residents. Our observations in nursing homes have shown that nurses split 15% of the medications they prepare (own unpublished observations, 2006). To this end, various methods are used: (i) a splitting device (e.g. Pilomat®), (ii) splitting by hand (for scored tablets) or with scissors (for unscored tablets), or (iii) with a kitchen knife. There has been previous research on the impact of tablet-splitting on dose accuracy. Reports published so far have concerned splitting devices (Peek *et al.* 2002, Cook *et al.* 2003, Boggie *et al.* 2004), kitchen knives (Cook *et al.* 2003) and splitting by hand (Babington 1997, Boggie *et al.* 2004). However, no researchers have compared the weight uniformity of all splitting methods used in nursing homes. Such data are necessary to provide nursing homes with advice on the best possible splitting technique.

Table 1 Characteristics of the volunteers

Volunteer	Gender	Age (years)	Training level	Splitting experience?
1	M	55	Laboratory technician	Yes
2	F	37	Administrative coworker	No
3	M	37	Pharmacist, professor	No
4	F	21	Pharmacy student	No
5	F	24	Pharmacist, researcher	No

The study

Aim

The aim of the study was to quantify (i) the mean deviation from theoretical weight and (ii) the mean weight loss, after tablet-splitting with three different, commonly used splitting methods.

Design

An experimental design was adopted and the data were collected in 2007.

Participants

Five volunteers (two men and three women aged 21–55 years) were recruited among the co-workers at the faculty to perform the splitting. Details are displayed in Table 1.

Data collection

Eight commercially available tablets of different sizes and shapes, and which are commonly split in nursing homes, were selected for the experiment. Table 2 gives an overview of the characteristics of these tablets. Marcoumar® and Marevan® were selected because of the therapeutic schemes that are meticulously titrated and they require frequent splitting. Medrol® and Zestril® were selected because they are mainly split for economic reasons. The four remaining tablets were included because experienced nurses indicated that the tablets often cause problems during splitting (Lanoxin® is a very small tablet of 5·6 mm, Merck-Metformine® is a big round tablet without scoring lines, Aldactone® is a coated tablet, and

Table 2 Tablet characteristics

Product	Active ingredient	Number of score lines	Shape	Flat?	Split into
Marevan®	Warfarin	1	Round	Yes	2
Lanoxin®	Digoxin	0	Round	Yes	2
Merck-Metformine®	Metformin	0	Round	No	2
Sinemet®	Levodopa + carbidopa	1	Oblong	No	2
Marcoumar®	Fenprocoumon	2	Round	Yes	4
Aldactone®	Spironolactone	0	Round	No	4
Medrol®	Methylprednisolone	2	Oblong	No	4
Zestril®	Lisinopril	1	Round	No	4

splitting Sinemet® causes important losses). Nevertheless, these tablets are often prescribed in halves or quarters. Four formulations were designated to be split in halves, four others had to be split in quarters, according to previous observations in nursing homes (own unpublished observations, 2006). Three different routine splitting methods were assessed: (i) a splitting device (Pilomat®, which is the most frequently used commercially available device in Belgium), (ii) scissors for unscored tablets or hand-splitting of scored tablets and (iii) a kitchen knife. No specific splitting guidelines or instructions were given. Per volunteer and per method, the initial weight of ten tablets of each formulation was assessed using an electronic analytical balance (Mettler Toledo AG 245), and the mass of each tablet was recorded with an accuracy of 0·1 mg. After splitting, each half or quarter (depending on the formulation) was individually weighed. For each tablet part, the deviation from the theoretical weight and the weight loss were calculated as follows: theoretical weight = weight of the tablet before splitting/2 or 4 (depending on the tablet); deviation (%) from theoretical weight = (weight of the tablet fragment − theoretical weight)/theoretical weight × 100; weight loss = weight of the tablet before splitting − sum of all (2 or 4) tablet fragments.

Ethical considerations

The study did not require approval from an ethics committee since we did not collect patient data.

Data analysis

Percent variation and percent weight loss among the three splitting methods were compared with a one-way ANOVA test and Tukey's *post hoc* test, using SPSS version 17.0 for Windows (SPSS, Inc., Chicago, IL, USA).

Results

Table 3 displays the mean deviation from the theoretical weight for the different tablet parts of each product and the comparison between the three different methods, using a one-way ANOVA test and Tukey's *post hoc* test. Overall results (grouping the different formulations) are also given. Overall, method 1 provides a significantly lower mean deviation from theoretical weight. The difference between method 2 and method 3 is not statistically significant.

Table 4 displays the number of tablet parts that deviate between 15% and 25% from theoretical weight, and the number of tablet parts that deviate more than 25% from the theoretical weight. While using the third splitting method, that is, splitting with a kitchen knife, some tablet fragments fell on to the floor. These fragments were no longer included in the data processing. As the results show, method 1 produced the smallest number of tablet parts deviating between 15% and 25% from theoretical weight and deviating more than 25% from theoretical weight.

Not only weight deviations from theoretical weight, but also weight losses were recorded. These results are summarized in Table 5. Method 1 gave the lowest weight loss of all three methods only for Lanoxin®. For Marevan®, Sinemet®, Marcoumar®, Medrol® and Zestril®; the difference between methods 1 and 2 was not statistically significant: both gave a smaller weight loss compared to method 3. For one tablet (Merck-Metformine®), there was no significant difference between the three methods. For the

Table 3 Mean and maximum deviation from theoretical weight (%) for the three evaluated methods (N = 50)

	Method 1			Method 2			Method 3			*P* value*	*P* value*	*P* value*
Drug	Mean	SD	Max	Mean	SD	Max	Mean	SD	Max	Method 1 vs. 2	Method 1 vs. 3	Method 2 vs. 3
Marevan®	5·55	6·32	26·47	12·43	10·61	34·82	6·89†	5·45	27·83	**< 0·001**	0·677	**0·002**
Lanoxin®	6·64	6·06	24·02	18·94	13·01	51·07	17·52	14·38	68·01	**< 0·001**	**< 0·001**	0·819
Merck-Metformine®	10·43	10·14	50·04	17·50	10·06	43·55	14·58	9·35	34·09	**0·001**	0·093	0·302
Sinemet®	5·65	4·74	23·28	5·75	4·77	21·49	**8·30**	14·34	53·18	0·999	0·321	0·347
Marcoumar®	11·08	9·86	55·11	11·44	9·77	35·29	12·54	11·53	53·17	0·984	0·767	0·859
Aldactone®	11·43	10·06	38·38	18·79	13·64	57·73	20·45	14·03	57·36	**0·012**	**0·002**	0·792
Medrol®	11·75	9·85	46·44	22·27	20·26	85·98	12·87	10·09	41·02	**0·001**	0·919	**0·003**
Zestril®	13·77	12·79	58·48	**14·58**	12·51	48·00	16·02	12·99	53·83	0·947	0·655	0·840
Overall	9·54	9·48	58·48	15·21	13·35	85·98	13·68	12·54	68·01	**< 0·001**	**< 0·001**	0·163

Method 1: with a splitting device; Method 2: with scissors or by hand; Method 3: with a kitchen knife.
*one-way ANOVA, *post hoc*: Tukey test.
†N = 48.
Statistically significant values are given in bold.

Table 4 Number of tablet fragments deviating more than 15% and more than 25% from the theoretical weight

	Method 1		Method 2		Method 3	
Drug	Deviation 15–25%	Deviation >25%	Deviation 15–25%	Deviation >25%	Deviation 15–25%	Deviation >25%
Marevan®	6/100	2/100	16/100	19/100	4/96*	1/96*
Lanoxin®	9/100	0/100	24/100	30/100	23/100	19/100
Merck-Metformine®	10/100	10/100	29/100	16/100	24/99*	16/99*
Sinemet®	2/100	0/100	5/100	0/100	2/100	2/100
Marcoumar®	40/200	20/200	66/200	23/200	28/200	23/200
Aldactone®	41/200	17/200	33/200	38/200	34/200	66/200
Medrol®	28/200	17/200	44/200	57/200	45/195*	24/195*
Zestril®	23/200	29/200	43/200	43/200	41/196*	47/196*
Overall	159/1200	95/1200	260/1200	226/1200	201/1186	198/1186

Method 1: with a splitting device; Method 2: with scissors or by hand; Method 3: with a kitchen knife.
*Tablet fragments that fell on the floor during splitting were no longer included.

Table 5 Weight-loss after tablet-splitting (%), with comparison between the three methods evaluated ($N = 50$)

	Method 1			Method 2			Method 3			*P* value*	*P* value*	*P* value*
Drug	Mean	SD	Max	Mean	SD	Max	Mean	SD	Max	Method 1 vs. 2	Method 1 vs. 3	Method 2 vs. 3
Marevan®	−0·93	0·92	−4·07	−0·72	2·27	−15·85	−2·17	3·41	−17·72	0·897	**0·031**	**0·009**
Lanoxin®	−1·44	2·06	−8·19	−7·55	8·43	−36·95	−5·37	8·00	−37·61	**<0·001**	**0·012**	0·249
Merck-Metformine®	−1·75	5·08	−26·60	−1·71	2·35	−11·65	−1·41	2·47	−11·24	0·998	0·884	0·907
Sinemet®	−0·46	0·44	−2·51	−0·10	0·32	−1·55	−2·25	4·74	−27·40	0·799	**0·004**	**<0·001**
Marcoumar®	−2·03	2·54	−9·87	−0·56	1·14	−6·53	−4·52	4·65	−15·93	0·053	**<0·001**	**<0·001**
Aldactone®	−2·28	1·86	−10·16	−4·80	3·34	−16·11	−3·40	2·76	−11·91	**<0·001**	0·103	**0·030**
Medrol®	−0·47	1·72	−6·57	−0·95	2·01	−9·61	−3·63	3·47	−13·92	0·601	**<0·001**	**<0·001**
Zestril®	−0·76	1·54	−6·33	−1·49	0·97	−5·11	−4·07	2·98	−11·87	0·165	**<0·001**	**<0·001**
Overall	−1·56	2·48	−26·60	−2·36	4·30	−36·95	−3·42	4·55	−37·61	**0·016**	**<0·001**	**<0·001**

Method 1: with a splitting device; Method 2: with scissors or by hand; Method 3: with a kitchen knife.
*One-way ANOVA, *post hoc*: Tukey test.
Statistically significant values are given in bold.

remaining tablet (Aldactone®), there was no statistically significant difference between methods 1 and 3, both giving a smaller weight loss than method 2. However, when pooling the results for the different tablets, method 1 induced statistically significantly less weight loss than the other two methods.

Discussion

Study limitations

This study had some limitations. It could be argued that we did not compare three distinct methods, since method 2 consisted of splitting by hand whenever the tablet had a score line or with scissors when the tablet was unscored. However, we wanted to compare three routine methods in order to identify the best possible splitting guidelines for daily practice. Another criticism might be that no nurses were included in the volunteer group. However, splitting is not always performed by professional nurses. Therefore, we chose to include an administrative coworker with no scientific background or splitting experience, a laboratory technician used to splitting his own medication, a pharmacy student who was still in training, and two pharmacists. We believe that this group was heterogeneous enough to simulate the nursing home environment. If there was any bias, it might have been a positive one, meaning that our volunteers might have split the tablets more accurately than would have been done in daily nursing home practice. Moreover, we did not investigate the clinical effect of the weight deviations. It seems logical that clinical consequences are small in long-term therapies with agents with long half-lives or high therapeutic indexes. This has been shown for lisinopril in hypertension therapy and HMG-CoA reductase inhibitors

What is already known about this topic

- Tablet-splitting is common practice in all sectors of health care.
- Literature has shown that large dose deviations and weight losses can occur during splitting.
- Extrapolation of the results from previous studies to daily practice is difficult.

What this paper adds

- Use of a splitting device gives a significant lower mean deviation from theoretical weight than the two other methods.
- Use of a splitting device induces significantly less weight loss than splitting by hand (for scored tablets) or with scissors (for unscored tablets), than splitting with a kitchen knife.

Implications for practice and/or policy

- The use of a splitting device is recommended as routine method when splitting cannot be avoided.
- Pharmacists should give clear messages about the risks related to splitting.
- Manufacturers could avoid the need for splitting by introducing a wider range of tablet doses or liquid formulations.

(simvastatin, atorvastatin and lovastatin) in the treatment of hypercholesterolemia and hyperlipidemia (Duncan *et al.* 2002, Gee *et al.* 2002). However, there might be some serious clinical consequences when a splitting method is used that produces important dose deviations, for acute therapies, or for drugs with short half-lives or low therapeutic indexes. We believe, however, that these limitations do not undermine the reliability of our advice to nursing homes.

Effects of tablet-splitting

Splitting tablets leads to high variability in both fragment weights and weight losses. This study was undertaken to evaluate the best method for daily tablet-splitting in nursing homes. Although some literature is available on this topic, authors have reported their findings in different ways, making comparison difficult. Some have reported deviation ranges (Cook *et al.* 2003), while others have reported the percentage of tablet fragments deviating more than 10% or 20% from theoretical weight (Mcdevitt *et al.* 1998), mean deviations (Boggie *et al.* 2004) or maximum losses (Biron *et al.* 1999). Some studies focused on only one splitting method or type of drug (Mcdevitt *et al.* 1998, Biron *et al.* 1999), while others compared different methods (Peek *et al.* 2002, Teng *et al.* 2002, Cook *et al.* 2003) or different tablets (Polli *et al.* 2003, Boggie *et al.* 2004, Kayumba *et al.* 2006). The majority of this literature is a few years old now, whereas the practice remains very alive and still problematic. Moreover, as stated before, we did not find any study that used our second method, that is, splitting by hand for scored tablets or with scissors for unscored tablets. The relevance of these diverse literature data to daily nursing practice is therefore not obvious, whereas the research question at the basis of our experiment was actually quite simple. We aimed at providing nursing homes with advice for the best splitting technique *in daily practice*. This means that we needed to search for a technique that is applicable and reliable regardless of the dexterity or training level of the person performing the splitting, and regardless of the tablet's characteristics. Indeed, in nursing home settings, splitting can be performed by experienced or newly graduated nurses, by pharmacists or sometimes even by nursing aides, all with different splitting skills. Therefore, we chose a heterogeneous sample of volunteers for our experiment. Moreover, only one method should be advised for all kinds of tablets in daily practice. Using different methods for different types of formulations would be confusing and would induce errors. Therefore, we selected tablets with different characteristics (including a generic brand: Merck-Metformine) to be included in the study. In this way, the findings can be generalized, regardless of the tablet or its brand. This is important, given the move to use generic rather than proprietary brands. Five volunteers, each splitting ten tablets of each type with the three different methods (in total, 1200 tablets were split), formed a reasonable sample size.

The results showed a high variability in weight deviation and weight loss between the different methods. The use of a splitting device appeared to be the best method for splitting tablets, since it yielded smaller weight deviations and smaller weight losses than using scissors for unscored tablets (and hand splitting for scored tablets) or using a kitchen knife.

Conclusion

Tablet-splitting is daily practice in nursing homes. However, not all formulations are suitable for splitting, and even when they are, large dose deviations or weight losses can occur. This could have serious clinical consequences for medications with a narrow therapeutic-toxic range. On the basis of our results, we recommend use of a splitting device when splitting

cannot be avoided (i.e. for example when the prescribed dose is not commercially available, or when there is no alternative formulation, such as a liquid). Nursing home staff performing the splitting should also be educated in splitting as accurately as possible, and should be aware of the possible clinical consequences of dose deviations. As for policy implications, we recommend that manufacturers make it possible to avoid splitting, by introducing a wider range of tablet doses or liquid formulations.

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Conflict of interest

No conflict of interest has been declared by the authors.

Author contributions

CV, EM and JPR were responsible for the study conception and design. CV performed the data collection. CV and EM performed the data analysis. CV, EM, KB, JPR and MP were responsible for the drafting of the manuscript. CV, EM, KB, JPR and MP made critical revisions to the paper for important intellectual content. CV, EM and KB provided statistical expertise. JPR provided administrative, technical or material support. KB, JPR and MP supervised the study.

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