TEACHING INNOVATIONS

Corn? When did I eat corn? Gastrointestinal transit time in health science students

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Abstract

The objective of this study was to determine gastrointestinal transit time in first-year health science students with a laboratory practical exercise conducted in two cohorts (classes of 2018 and 2019) of first-year health sciences students at the Health Science Campus in Windhoek, Namibia. All first-year health science students undertaking the Physiology course were invited to take part in the laboratory exercise. The primary outcome was the measurement of gastrointestinal transit time from the amount of time taken for ingested whole-kernel sweetcorn to be eliminated, which was calculated as the time period between ingestion of corn and the time of corn first seen in the stool and the time corn was last seen in the stool. The secondary outcome was an association between emotional irritability and/or anxiety and gastrointestinal transit time. The study analyzed responses of 175 students, who reported a median transit time of 29 (1–99) h. There was no difference in gastrointestinal transit time between male and female students. Likewise, there was no difference in the duration of the corn in the bowel between male and female students. Students who reported being worried and irritable during the exercise had more bowel movements before they saw corn in their stool and had slower transit times, respectively. A wider range of transit time was reported in a group of young, healthy students compared with previous studies in the literature. There were no differences between male and female student bowel activity. Anxiety did impact the bowel activity of the participants.

education; gastrointestinal; transit time

INTRODUCTION

In clinical practice, patients often ask whether their own bowel movements are considered normal. Clinicians reassure patients that a general range of five to seven times a week is normal. However, the current literature publishes variable ranges of transit time. The common stated normal transit time is 24–48 h, which is often misinterpreted as being the period between bowel movements. Although this concept may seem trivial, it is a crucial concept for medical students and clinicians to understand so as to avoid misdiagnosis of atypical bowel movements. There is, however, a lack of data regarding normal transit time, especially in southern Africa, with only a few studies (1, 2) conducted over four decades ago.

Transit time is measured by different techniques, including the ingestion of a substance that can be tracked as it travels along the gastrointestinal tract or is seen upon elimination from the body (3). The measurement of transit time is also dependent on the frequency of bowel movements as well as the structure of the ingested material (4). Another proxy used to determine transit time is the Bristol stool chart, which describes the different types of stool shapes (5). The importance of stool shape and consistency was demonstrated in a study (6) that showed a tendency for persons with slower transit times to have hard, lumpy stool shapes, whereas persons with faster transit times had looser, watery stool shapes. The relationship between stool shape and gastrointestinal transit time was also validated by Lewis and Heaton (5), who showed that slow transit time resulted in constipation (i.e., characterized by hard, lumpy stool shapes). Although this method was peculiar, it was a more convenient way for clinicians and researchers to determine gastrointestinal transit time, with the main concern being how to persuade participants to examine their own stool.

We planned a simple exercise using whole-kernel sweetcorn to measure student transit time. Whole-kernel sweetcorn is composed mainly of cellulose in the outer shell (the yellowish hull) of the kernel. Cellulose is a dietary component that is thought to escape digestion in the human body, unlike in ruminants, because of the lack of cellulases in the human colon (7). Therefore, the principal aim of this study was to demonstrate and record transit time in healthy first-year university students with whole-kernel sweetcorn.

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METHODS

Participants

The transit time exercise took place in the first-year physiology laboratory as part of a first-year physiology laboratory exercise for 2018 and 2019 first-year cohorts. In 2018 the first-year physiology class had a total of 229 students, whereas the 2019 physiology class had a total of 221 students. Of the 229 physiology students in 2018, 177 participated in the transit time exercise, 52 students did not participate, 37 students did not return their data sheets, and 15 students were excluded because of invalid data. In 2019, 180 students participated in the exercise, 41 students did not participate, 89 students did not return their data sheets, and 4 students were excluded because of invalid data. Additionally, in our medical physiology course, during the gastrointestinal teaching block we often received questions from students about their own bowel habits and queries about the “normality” of their experiences. Thus, as part of our curriculum we designed a practical laboratory to accompany the block teaching in order to illuminate the range of transit times, variation in stool shape and character, as well as association with students’ anxiety.

Pilot Study: Dose Response

We conducted a pilot study in 2018 to determine the minimal ingested amount of corn that would be reliably, and somewhat comfortably, visible in stool. The pilot study was conducted with 50 participants (i.e., both staff and students), both male and female, who were recruited from the Health Sciences campus. Five different doses (i.e., 25 g, 50 g, 75 g, 100 g, and 150 g) of SPAR whole-kernel sweetcorn (Fig. 1) bought from a local supermarket (SPAR, Pinetown, South Africa) were used in this pilot. Ten participants were tested at each dose of corn.

Main Exercise

Students who were allergic to corn or had any other conditions for which corn ingestion was contraindicated were encouraged to not participate. Students who had ingested corn within 48 h of the exercise were also excluded from the exercise.

The exercise took place in the physiology laboratory, where all the students received a consent form and a data sheet. In the 2018 group the students received a data sheet, whereas in 2019 the students received both a data sheet and a survey, adapted from General Anxiety Disorder-7 scale (8), which they had to complete. The change in data collection was prompted by student feedback and queries about the relationship between emotional state and bowel function.

The students were briefed about the procedure before taking part in the exercise. The students had to record their age, sex, and anthropometric measures (i.e., height and weight) on their data sheets. The students were then instructed to record the dates and times of when they ingested corn, when they first saw corn in their stool, and when they last saw corn in their stool. The data sheet also included a section where students could note any additional comments.

Students who consented and took part in the exercise (n = 177 in 2018; n = 180 in 2019) were instructed to ingest 75 g of whole-kernel sweetcorn either without chewing or with minimal chewing. The participants were also allowed to wash down the corn with a liquid.

The survey conducted in 2019 had multiple-choice questions only, with the aim of being easier for students to complete. The survey focused on three aspects: the student’s performance in the module, the Bristol stool chart (Fig. 2; Ref. 5), as well as questions querying the student’s anxiety.

Ethics

Students who participated in the exercise gave written informed consent. The University of Namibia Human Research Ethics Committee evaluated the exercise and manuscript, exempted this learning experience from further review, and provided permission to the investigators.

Figure 1. Nutritional information for whole-kernel sweetcorn and a 75-g dose of corn.

| Nutritional Value                      | Per 100g | Per single serving 75g |
|----------------------------------------|----------|-----------------------|
| Energy (kJ)                            | 300      | 225                   |
| Protein (g)                            | 3.8      | 5.6                   |
| Glycaemic carbohydrate (total sugar) (g) | 8(4.1)   | 6.2(3.1)              |
| Total fat (saturated fat) (g)           | 2.0 (0.5) | 1.5(0.4)             |
| Dietary fibre (g)                      | 3.0      | 2.3                   |
| Total sodium (g)                       | 209      | 157                   |

Ingredients: Corn (60%), water, sugar, salt and no allergens.
Data were analyzed with IBM SPSS (version 24). The data were not normally distributed and are thus presented as medians (ranges) unless otherwise stated. Transit time was calculated as the time difference (hours) between corn ingestion and corn first seen in stool. The duration of corn in the bowel was determined as the time difference (hours) between corn last seen in stool and corn first seen in stool. Correlations between transit time or duration of corn in the bowel and the reported anxiety parameters were determined with the Pearson correlation analysis. Determinations of differences in transit time among different types of stool shapes were made with the Kruskal–Wallis $H$ test. The data summarized in this paper are available upon request (identifying information has been removed). We excluded values from nine students who reported transit times that were considered as outliers (transit time $>119$ h).

## RESULTS

### Dose Response

All 50 participants from the pilot study (Fig. 3) returned their data sheets. Of note, the majority of participants who ingested 100 g (10 of 10) and 150 g (9 of 10) saw corn in their stool. However, subjects at these two doses reported difficulty with ingesting that amount of corn. Eight of the ten participants who ingested 50 g saw corn in their stool, whereas seven of the ten participants who ingested 75 g saw corn in their stool. The dose of 75 g was chosen as it was a large enough dose of corn to appear in the stool and had fewer reports of discomfort from the participants.

### Main Exercise

Data from a total of 197 students (113 from the 2018 class and 84 from the 2019 class) were analyzed. The characteristics of the participating students are described in Table 1. Students reported to have a median of 4 (range 1–21) bowel movements per week. Additionally, the number of bowel movements reported before students saw corn in their stool was 1 (range 0–8). The median transit time reported by the participants ($n = 175$) was 29 (range 1–99) h (Fig. 4, A and B).

### Table 1. Overall student demographics

| Characteristics         | Students, means ± SD ($n = 197$) | Median (range) | Interquartile Range |
|-------------------------|-----------------------------------|----------------|---------------------|
| Age, yr                 | 20 ± 2                            | 19 (17–29)     | 1                   |
| Sex (female/male)       | 159/38                            |                |                     |
| Weight, kg              | 58.4 ± 10.7                       | 57.0 (42.0–94.0)| 13.0                |
| Height, cm              | 165.8 ± 9.3                       | 165.0 (130.0–192.0)| 10.9                |
| Body mass index, kg/m² | 27.5 ± 8.6                        | 25.3 (15.4–57.0)| 14.0                |
Furthermore, the duration of corn in the bowel was reported as the time period from when corn was first seen in the stool until corn was last seen in the stool. The median duration of corn in the bowel was reported as 36 (0–166) h. The characteristics of male and female participants were compared (Table 2). In the 2018 cohort, of the 113 who participated 101 observed corn in their stool. In the 2019 cohort, 84 participated and 82 reported observing corn in their stool.

There was a correlation between the number of bowel movements before participants reportedly first saw corn in the stool and the transit time \( (r = 0.29; P < 0.001) \). There was also a positive correlation between number of bowel movements before corn was first seen and the participant’s height; however, this was not statistically significant \( (r = 0.13; P = 0.08) \). Although there was no significant difference in transit time between male and female students \( (P = 0.4) \), female students reported having slower transit times. Similarly, there was no significant difference in the duration of corn in the bowel between male and female students \( (P = 0.64) \), with female students again reporting a longer duration of corn in the bowel.

Finally, the 2019 survey data included a Bristol stool chart (5) that the students used to record their normal stool shape (Fig. 2) as well as their stool shape in the week of the exercise (Table 3). The majority of students reported a type 3 stool shape (Fig. 4C). We ran the nonparametric Kruskal–Wallis test to determine whether there were any differences in transit time according to stool shape and found no differences (chi square = 6.02, df = 6, \( P = 0.42 \)). The students’ emotional state during the exercise was also correlated to their transit time and bowel movements (Table 4).

Table 2. Differences between male and female students

| Characteristics   | Female Students \( (n = 159) \) | Male Students \( (n = 38) \) | \( P \) Value |
|-------------------|-------------------------------|------------------|------------|
| Age, yr           | 19 (17–29)                    | 19 (17–27)       | 0.486      |
| Weight, kg        | 54.8 (40.0–94.0)              | 62.0 (43.0–90.0) | <0.001*    |
| Height, cm        | 163.7 (130–180)               | 177.1 (165.0–192.0) | <0.001*  |
| Body mass index, \( \text{kg/m}^2 \) | 25.0 (15.4–57.0) | 24.5 (15.7–52.3) | 0.868 |

*Significance at the 0.01 level.
reported being worried during the week of the exercise were found to have more bowel movements before corn was first seen in the stool ($r = 0.29; P = 0.01$). Similarly, students who reported being irritable during the week of the exercise also had a longer transit time ($r = 0.33; P = 0.002$).

**DISCUSSION**

We know that corn kernels can at times be seen in stool and may be used as a marker for measuring bowel transit time (9). We observed this response in our gastrointestinal physiology practical. Transit time was measured in two cohorts of first-year students who were registered for the first-year physiology course at the University of Namibia. Initially, this study only recorded the physiological measurements in the first student cohort and then went on to include a student survey [including the Bristol Stool chart (Fig. 2)] along with the physiological measurements for the second student cohort. Overall there was a wider range in transit time reported among the participants compared with those reported in previous studies (Fig. 4) (1–3, 10, 11).

The wide range in transit time should not be surprising, as the data were all self-reported and depended on the students’ continued participation. Another factor contributing to the large range in transit time could be that some students may have misreported their times. This study also found that the majority of students had the same stool shape before and during the exercise, which is in agreement with Tagg et al. (11), suggesting that corn ingestion did not significantly affect the shape of the stool. Lewis and Heaton (5) correlated stool shape with bowel activity, i.e., stool types 1 and 2 were associated with slower bowel transit, types 3 and 4 were associated with normal bowel transit, and types 5–7 were associated with faster bowel transit. Unlike their results, our study did not show an association between stool shape and transit time. Our results may differ because not all students reported their stool shapes and some students may have experienced errors in observation when identifying their stool shapes (5).

We also queried whether students’ emotional state during the exercise impacted their bowel movements. Students who reported feeling worried during the exercise had more bowel movements before they saw corn in their stool, which is consistent with findings from an older study (10). Similarly, students who reported being irritable during the exercise had a slower transit time. The discomfort of examining one’s stool may have contributed to the anxiety and irritability that students felt.

Our study was able to measure gastrointestinal transit time with corn kernels and found a wider range of transit time among healthy students. There was no difference in bowel activity between male and female students, which may be due to fewer male participants. We also confirmed that anxiety is associated with bowel activity: specifically, students who were worried had more frequent bowel movements before they saw corn in their stool and irritable students had longer bowel transit. Although this is an unusual way to measure gastrointestinal transit, it is easy enough for students or patients who need to know their normal transit time. Healthy young adults have a broad range of gastrointestinal transit time, and reporting a single average value may concern many who have transit time values beyond the average value.

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**Table 3. Student stool shapes before and during the laboratory exercise**

| Stool Shape | Usual Stool Shape | Stool Shape during Week of Laboratory Exercise |
|-------------|-------------------|-----------------------------------------------|
| Type 1      | 1                 | 2                                             |
| Type 2      | 15                | 16                                            |
| Type 3      | 42                | 30                                            |
| Type 4      | 20                | 11                                            |
| Type 5      | 4                 | 7                                             |
| Type 6      | 1                 | 7                                             |
| Type 7      | 0                 | 1                                             |

**Table 4. Relationship between bowel movements and emotional state**

| Emotional Parameters | No. of Students | R Value | P Value |
|----------------------|-----------------|---------|---------|
| I felt tense.        |                 |         |         |
| No. of bowel movements before corn seen in stool | 77 | 0.064 | 0.582 |
| Transit time         | 82              | 0.008  | 0.945  |
| Duration of corn in the bowel | 82 | −0.064 | 0.567 |
| I felt worried.      |                 |         |         |
| No. of bowel movements before corn seen in stool | 77 | 0.285 | 0.012* |
| Transit time         | 82              | 0.169  | 0.129  |
| Duration of corn in the bowel | 82 | −0.059 | 0.598 |
| I had difficulty sleeping. |             |         |         |
| No. of bowel movements before corn seen in stool | 77 | 0.022 | 0.847 |
| Transit time         | 82              | 0.158  | 0.156  |
| Duration of corn in the bowel | 82 | 0.045 | 0.691 |
| I was fatigued.      |                 |         |         |
| No. of bowel movements before corn seen in stool | 76 | 0.06  | 0.604  |
| Transit time         | 81              | 0.081  | 0.471  |
| Duration of corn in the bowel | 81 | −0.136 | 0.227 |
| I was irritable.     |                 |         |         |
| No. of bowel movements before corn seen in stool | 77 | 0.074 | 0.524 |
| Transit time         | 82              | 0.331  | 0.002**|
| Duration of corn in the bowel | 82 | −0.03 | 0.792  |

*Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level.
DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

C.J.H. conceived and designed research; T.P.T.K., H.H.E., and T.E.N. performed experiments; T.P.T.K., T.W.R., and C.J.H. analyzed data; T.P.T.K., H.H.E., T.W.R., and C.J.H. interpreted results of experiments; T.P.T.K., T.E.N., and C.J.H. prepared figures; T.P.T.K. drafted manuscript; T.W.R. and C.J.H. edited and revised manuscript; C.J.H. approved final version of manuscript.

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