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Understanding pharmacokinetics: are YouTube videos a useful learning resource?

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Abstract. – OBJECTIVES: To investigate whether YouTube videos on pharmacokinetics can be a useful learning resource for medical students.

METHODS: YouTube was searched from 01 November to 15 November 2013 for search terms "Pharmacokinetics", "Drug absorption", "Drug distribution", Drug metabolism", "Drug elimination", "Biliary excretion of drugs", and "Renal excretion of drugs". Only videos in the English and those matching the inclusion criteria were included. For each video, the following characteristic data were collected: title, URL, duration, number of viewers, date uploaded, and viewership per day, like, dislike, number of comments, number of video sharing, and the uploader /creator. Using standardized criteria comprising technical, content, authority and pedagogy parameters, three evaluators independently assessed the videos for educational usefulness. Data were analyzed using SPSS software and the agreement between the evaluators was calculated using Cohen's kappa analysis.

RESULTS: The search identified 1460 videos. Of these, only 48 fulfilled the inclusion criteria. Only 30 were classified as educationally useful videos (62.5%) scoring 13.83±0.45 (mean±SD) while the remaining 18 videos were not educationally useful (37.5%) scoring 6.48±1.64 (mean±SD), $p = 0.000$. The educationally useful videos were created by pharmacologists/educators 83.3% (25/30), professors from two universities 13.3% (04/30) and private tutoring body 3.3% (01/30). The useful videos were viewed by 12096 (65.4%) and had a total of 433332 days on YouTube, while the non-educationally useful videos were viewed by 6378 (34.6%) viewers and had 20684 days on YouTube. No correlation was found between video total score and number of like (R^2 0.258), dislike (R^2 0.103), viewers (R^2 0.186), viewership/day (R^2 0.256), comments (R^2 0.250), or share (R^2 0.174). The agreement between the three evaluators had an overall Cohen's kappa score in the range of 0.582-0.949.

CONCLUSIONS: YouTube videos on pharmacokinetics and drug elimination showed a range of variability in regard to the contents of their educational usefulness. Medical educators should be aware of the potential influence of YouTube videos may have on student's understanding of pharmacokinetics and drug elimination. Users who rely on the comments made by viewers or the approval expressed in terms of the number of like given by viewers should become aware that these indicators are not accurate and do not correlate with the scores given to videos.

Key Words:

YouTube, Pharmacokinetics, Pharmacology, Drug elimination, Drug absorption, Drug distribution, Drug metabolism, Learning resources, Medical education, Medical curriculum, Self-regulated learning, Problem-based learning.

Introduction

Pharmacokinetics is a quantitative discipline that involves understanding the time course of drug concentrations attained in different regions of the body during and after dosing[1]. This necessitates application of mathematical principles to describe drug absorption, distribution, metabolism and excretion/elimination from a body system with the aim to predict drug behavior in patient populations[2]. Therefore, knowledge of pharmacokinetics is crucial for drug development and understanding preclinical toxicity testing as well as to decide on an appropriate dosing regimen and identify covariate influences on human pharmacokinetics; which are important for potential dose adjustment and drug labeling[3]. Clinical pharmacology is the application of pharmacokinetic principles to the safe and effective management of drug treatment in patients[4,5]. This is important particularly in severely ill patients who need individualization of the dose regimen depending on how rapidly a physician needs a therapeutic plasma concentration to be reached and whether the clearance of the drug is impaired because of liver or kidney dysfunctions. Students typically find basic pharmacokinetics challeng-

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ing either because it requires mathematical skills or they do not understand how to bridge the gap between theory and clinical applications[6].

With the changes introduced to medical curricula and the introduction of self-regulated learning approaches to most medical curricula, students tend to use online resources such as YouTube in their search for knowledge[7-12]. Several studies showed that medical and allied health students prefer online learning resources rather than reading recommended textbooks and medical journals[13-16]. For example, students searching for their learning issues in a problem-based learning or case-based learning program usually start by searching Google[8]. While websites could provide students with topics related to their search that they can read, the accuracy of the contents, the reliability and the validity of the online resources cannot be guaranteed. While thousands of such resources are freely available and the users only need an Internet connection to their computers, most of these resources have not written by experts and there are no editors appointed to review them. For example, YouTube and Wikipedia websites have no experts or reviewers to edit/review the material and correct the scientific content prior to publication[17]. Furthermore, reading resources such as Wikipedia or textbooks may provide some factual knowledge but not necessarily foster understanding of difficult concepts or experience the application of knowledge learnt to clinical situations.

Several researchers have recently evaluated YouTube videos in relation to their use as a resource for clinical procedures[18], a learning resource for nurses[19], an anatomy resource on surface anatomy[20], in clinical examination of the cardiovascular and respiratory systems[21], burn first-aid[22], in dental education[23] and as a source of medical information on heart transplantation[24]. However, not all researchers found YouTube videos to be educationally useful videos and some videos may convey wrong messages[25]. The author is not aware of any study that has examined whether there are educationally useful YouTube videos on pharmacokinetics that can be used as learning resources. Therefore, the aim of this study was to assess YouTube videos covering pharmacokinetics.

Methods

YouTube (www.youtube.com) was searched independently by three evaluators (the author and two research assistants) from 01 November to 15 November 2013 for videos on pharmacokinetics. The following search words were used "Pharmacokinetics", "Drug absorption", "Drug distribution", "Drug metabolism", "Drug elimination", "drug biliary excretion", and "Drug renal excretion".

Exclusion Criteria

Videos were excluded if they were: (1) covering professional conferences on pharmacology, (2) an advertisement, (3) discussing pharmacokinetics of a particular drug as part of a research presentation, (4) covering general pharmacology issues, (5) created for lawyers and none healthcare professionals, (6) covering reflections made by PhD students about their research on pharmacokinetics, (7) discussing a textbook on pharmacology, (8) covering songs or dramas on pharmacokinetics and pharmacology.

The inclusion and exclusion criteria were implemented and only videos fulfilling the inclusion criteria were identified and placed on a new Excel sheet by each evaluator. The findings were discussed among the researchers in a meeting and a final Excel sheet was created covering a common pool for videos fulfilling the inclusion criteria from the work completed by the three evaluators. For each video, the following data were collected: title, URL, duration of the video, number of days on YouTube, total number of viewers, and name of uploader/creator (organization, group of people, one person). The number of "likes" and "dislikes", comments, and number of video sharing were recorded. Because the number of days on YouTube varies widely among videos, we decided to calculate viewership/day as a more accurate parameter compared to total number of viewers. The viewership per day is the ratio of number of viewers to the number of days a video is on YouTube. Only videos in English and those matching the inclusion criteria were included.

Criteria Used

The criteria used for grouping videos into educationally useful and non-useful videos have been tested and published in an earlier work[20,21]. The criteria were modified to match the needs of this work. In summary, the comprises major and minor items and can be summarized as follows: Major criteria: (1) the video uses clear graphs and or illustrations to explain the topic, (2) Contents about pharmacokinetics are scientifically

correct, (3) the images are clear, (4) the topic is clearly presented, and enhances understanding, and (5) sounds are clear and the background is free from noise. The minor criteria comprise: (1) the vide covers the topic identified in the title, (2) the video is designed at the level of undergraduate medical/healthcare students, (3) time to download is reasonable (about 5-10 minutes at the maximum not interrupted or there are no challenges to download as reported by the three evaluators), (4) the educational objectives are stated, and (5) the creator/organization providing the video is mentioned.

"Educationally useful" means, the video provides scientifically correct and up-to-date knowledge, and its contents are accepted by educators in other teaching institutions and match with the current information in the literature. Therefore, it can be included as a teaching resource and can be used by students to complement their learning anywhere in the world.

As per earlier work[20,21], two scores were allocated for each item in the major criteria and one score was allocated to each item under the minor criteria. The reason for allocating two marks to items in the major criteria was the significance of these items and their ability of discrimination. If an item was fulfilled, an allocated score was given; if not fulfilled, a zero was given. No half scores were used. A video is grouped as educationally useful if all major criteria items were fulfilled together with at least three items from the minor criteria[20,21]. The maximum score is 15. The study on YouTube was approved by the Research Ethics Committee at King Saud University College of Medicine.

Piloting the Process of Evaluation

To ensure that each evaluator was oriented to the criteria, able to apply and use the criteria correctly in evaluating the videos, it was decided to pilot the criteria prior to applying it. A total of 20 videos (other than those identified but match with the purpose and scope of the study) were randomly selected and used for this purpose. The criteria were applied independently by each evaluator and the findings were placed on an Excel sheet. Any disagreement among the evaluators and for videos that were difficult to classify, the issues were discussed and resolved in a meeting. Concerns regarding the criteria items were also adjusted and changes were introduced accordingly. Another 20 videos were again evaluated and the findings were discussed again in a meeting. The piloting process helped in enhancing the use of the criteria and increasing the agreement among the three evaluators to > 95%.

Conducting the Video's Evaluation

The criteria were then applied by the three evaluators, independently, to the common pool of videos identified. The scores for each item were placed on an Excel sheet template. The findings were discussed in a meeting and disagreement among the evaluators, if any, was resolved through discussion.

Engagement parameters and Video Total Score

The following parameters for each video were considered in assessing user engagement: number of like, dislike, viewers, viewership/day, comments, and video sharing[26]. It was interesting to assess if any of these parameters correlate with the video total score and examine the degree of interdependence for each metric against others.

Statistical Analysis

Data was summarized on a Microsoft Excel 2010 sheet (Microsoft Corp., Redmond, WA) and were checked before conducting any analysis. The relative frequencies and continuous data such as mean with standard deviation or median with minimum and maximum were calculated. The ANOVA model was used to compare the means. Analysis was conducted with SPSS Software (version 18.0 for MS Windows, SPSS Inc., Chicago, IL, USA). To assess the degree to which different judges or raters agree in their assessment decisions, Cohen's kappa for inter-rater reliability was used to assess inter-rater reliability[27]. Pearson's correlation coefficient (r) was calculated to determine if there is a correlation between the engagement parameters and the video total scores[28,29]. For all calculations, a p value < 0.05 was considered significant.

Results

The search identified 2096 videos (search term pharmacokinetics = 352, drug absorption = 259, drug distribution = 27, drug metabolism = 382, drug elimination = 188, renal drug excretion = 163, biliary drug excretion = 89 videos). After excluding irrelevant videos, and on the basis of inclusion and excretion criteria, 48 videos were included in the study (Figure 1).

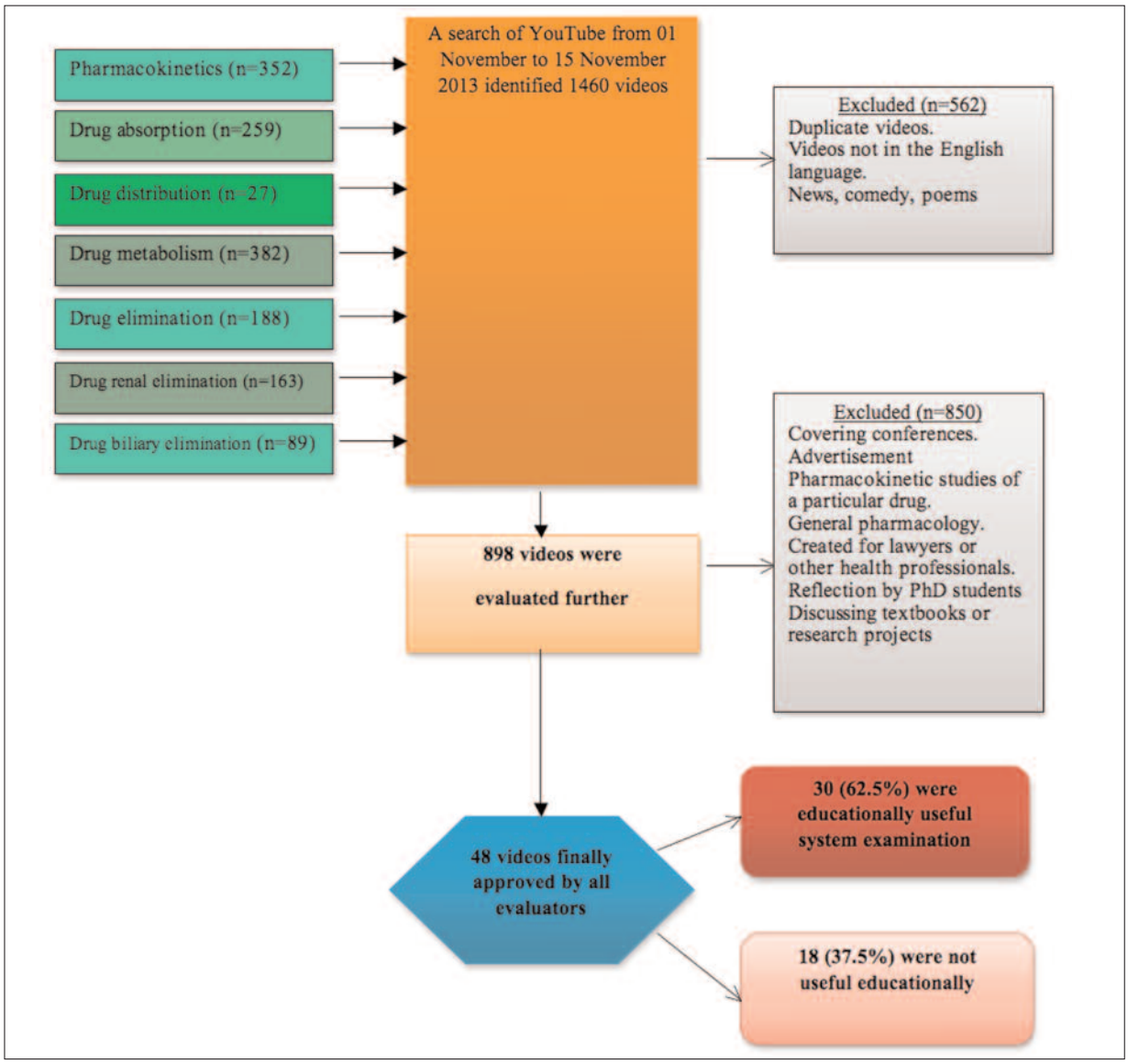

Figure 1. Searching YouTube for videos on pharmacokinetics.

Educationally Useful Videos

Table I summarises the descriptive statistics of the educationally useful videos. A total of 30 videos were educationally useful scoring 13.83±0.45 (mean±SD). The total duration of these videos was 351 minutes and 9 seconds. And the total views of these videos were 12096 (65.4%). The videos were for 433332 days on

Table I. Videos covering pharmacokinetics on YouTube.

Video	Number of videos (%)	Duration in minutes (seconds)	Total number of days on YouTube (mean, minimum, maximum)	Total number of viewer ship (%)	Total scores (mean ± SD)
Educationally useful	30 (62.5)	351 (09)	433332 (14444.4; 102; 87146)	12096 (65.4)	13.83 ± 0.45
Not useful	18 (37.5)	295 (07)	20684 (1149.1; 1; 4982)	6378 (34.6)	6.48 ± 1.64 $p = 0.000$

YouTube (mean = 14444.4; minimum = 102 and maximum = 87146). The educationally useful videos were created by pharmacologists/educators 83.3% (25/30), professors from two universities 13.3% (04/30) and private tutoring body 3.3% (01/30). Although the exact place/institute where these educators associate was not mentioned, the two professors were from the University of Pennsylvania, and the University of Colorado Boulder,

Non-Educationally Useful Videos

The remaining 18 (37.5%; 18/48) videos were non-educationally useful scoring 6.48±1.64 (mean±SD). The total duration of these videos was 295 minutes and 7 seconds and the total number of viewers was 6378 (34.6%; 6378/18474). The videos were for 20684 days on YouTube (mean = 1149.1, minimum = 1 and maximum = 4982), see Table I. Table II shows detailed information about the 48 videos included in the study. The majority of the non-educationally useful videos failed to fulfill one or more of the major criteria items.

Engagement Parameters and Video Total Score

Figure 2 (A to F) shows the correlation between engagement parameters and video total score. There were no correlations between total score and number of like (R^2 0.258), dislike (R^2 0.103), viewers (R^2 0.186), viewership/day (R^2 0.256), comments (R^2 0.250), or share (R^2 0.174). There were no correlation between like and dislike (R^2 0.292), dislike and comments (R^2 0.363) but there were correlation between like and share (R^2 0.567) and like and number of comments (R^2 0.740).

Agreement Between Evaluators

Table III summarises the agreement between the evaluators for each item in the major and minor criteria. The agreement was measured using Cohen kappa and had an overall score ranging from 0.582 to 0.949.

Discussion

The aim of this study was to assess the quality of YouTube videos available on the topic pharmacokinetics and whether there were educationally useful videos that can be used by students in their self-regulated learning and by teachers in their teaching sessions. The results show that there were 48 videos fulfilling the inclusion and exclusion criteria. Of these videos 30 were educationally useful and the remaining 18 were not educationally useful. The original number of videos identified using the key search words was 1460 indicates the limitation of YouTube search engine in filtering the videos searched by users. It also shows the wide range of videos covering a particular topic and the variability of the educational quality of videos. Based on the criteria used, the educationally useful videos had a score of 13.83±0.45 (mean±SD) and the non-useful videos had a score of 6.48±1.64. This is mainly because YouTube is freely available to anyone to upload their work and there are no reviewers or editors who can review submissions prior to releasing them to be viewed by the public. Furthermore it was demonstrated in this study that there were no correlation between the number of viewers or the viewership/day and the video total scores. Although it is difficult from the data provided by YouTube website to identify whether the same person had watched the video more than once, the findings indicate that many viewers may not be drawn in their search to videos with accurate content/educationally useful or they watched parts of the video only. Also there were no correlation between other engagement parameters including like, dislike, number of comments, number of video sharing and video total scores indicating that none of these parameters can help in identifying educationally useful videos, supporting the need for criteria to help in identifying educationally useful videos.

A number of methods were described in evaluating videos[26,30-32]. However, it was decided to use the system developed, piloted and tested by the author[20,21]. The decision to use the criteria in this study was not only based on the high reliability and high inter-rater correlation between evaluators but also because of the breadth of the coverage provided by the system (scientific content, technical, authority, and pedagogy) as well as being simple and easy to apply.

This study shows that out of the total number of videos, 30 were educationally useful. These videos had approximately 351 minutes and 9 seconds that can be used in learning and teaching purposes. These videos were linked to or produced by pharmacologists/educators, universities and professional bodies, indicating the role of universities and research institutes in knowledge transfer and providing useful educational resources that can be used

Table II. Details about the 48 YouTube videos, discussing pharmacokinetics, identified in the study.

No	Title	URL	Duration Min (Sec)	Viewers	Days on YouTube	Viewership/ day	Total score* mean ± SD
1	Pharmacokinetics 1 – Introduction	http://youtu.be/8-Qtd6RhfVA	05 (50)	43.980	418	105.21	14.67 ± 0.57
2	Pharmacokinetics 2 – Absorption	http://youtu.be/pWW-aq7iSa0	06 (35)	10.746	131	82.03	14.33 ± 0.57
3	Pharmacokinetics 3 – Distribution	http://youtu.be/6erefsWCVxg	05 (35)	22.656	349	64.91	14.67 ± 0.57
4	Pharmacokinetics 4 – Metabolism	http://youtu.be/ztsBn8gsfHw	05 (20)	21.650	332	65.21	14.33 ± 0.57
5	Pharmacokinetics 5 – Excretion	http://youtu.be/VZRVt9r4oSM	07 (04)	17.360	117	148.37	14.33 ± 0.57
6	What is Pharmacokinetics? ADME – Lect 1	http://youtu.be/CMRZqdrkCZw	16 (30)	31.262	454	68.85	14.33 ± 0.57
7	Drug Absorption Overview – Pharmacology Lect 2	http://youtu.be/eya9jR3v7i8	17 (14)	17.823	454	39.25	14.00 ± 0.00
8	Drug Bioavailability Overview – Pharmacology Lect 3	http://youtu.be/rv2Rpdi7OHM	16 (45)	13.680	454	30.13	14.33 ± 0.57
9	Drug Distribution Overview – Pharmacology Lect 4	http://youtu.be/DH2WGUd7MBs	16 (22)	14.252	454	31.39	13.67 ± 0.57
10	Volume of Distribution – Pharmacology Lect 5	http://youtu.be/B63sqUfvFQQ	22 (52)	19.349	453	42.71	13.67 ± 0.57
11	First Pass Metabolism – Pharmacology Lect 6	http://youtu.be/5AB8WkCbz4k	15 (15)	31.525	417	75.59	14.00 ± 1.00
12	Phase I Metabolism – Pharmacology Lect 7	http://youtu.be/GGLddVpVg9M	06 (56)	17.856	416	42.92	14.33 ± 0.57
13	Phase II Metabolism – Pharmacology Lect 8	http://youtu.be/iIWAUo05GFE	08 (28)	12.370	416	29.73	14.33 ± 0.57
14	First Order & Zero Order Elimination – Pharm Lect 9	http://youtu.be/XEotDfKhNTw	13 (27)	13.271	387	34.29	14.00 ± 1.00
15	Drug Half-life | An Overview – Pharm Lect 10	http://youtu.be/eTqPsqnbwoc	11 (43)	11.876	386	30.76	13.33 ± 0.57
16	First Order Elimination Rate Constant and Half-life | A closer look – Lect 11	http://youtu.be/De9999Jj-5Q	08 (15)	7.007	395	17.73	13.33 ± 0.57
17	Drug Clearance – Pharmacokinetics Lect 12	http://youtu.be/csywV3MYHDg	10 (36)	9.316	359	25.94	13.33 ± 0.57
18	Renal Excretion of Drugs | Pharmacokinetics Lect 13	http://youtu.be/8c3gqI6R-Vw	16 (47)	9.504	359	26.47	13.67 ± 1.15
19	Competitive Inhibition Overview – Pharmacokinetics Lect 17	http://youtu.be/iNIxMuHuL3w	07 (19)	2.976	407	7.31	13.33 ± 0.57
20	Competitive Inhibition & Statins – Pharmacokinetics Lect 18	http://youtu.be/Lt1-mjMFniE	12 (23)	2.429	397	6.11	14.33 ± 0.57
21	Enzyme Induction – Pharmacokinetics Lect 16	http://youtu.be/Dtbkc8F_ff0	17 (49)	4.971	410	12.12	13.67 ± 1.15
22	1 4 - 3. Absorption	http://youtu.be/d6FoURHtif0	29 (35)	265	190	1.39	13.67 ± 0.57
23	1 5 - 4. Distribution	http://youtu.be/jUtFbINuen0	25 (23)	134	190	0.70	14.33 ± 0.57
24	1 7 - 6. Excretion	http://youtu.be/7axj1W08zO	01 (04)	102	190	0.53	13.67 ± 0.57
25	259 FA 12: Pharmacokinetics equations PAR	http://youtu.be/tLsZEmVPgNQ	09 (59)	1.739	357	4.87	13.33 ± 0.57

Table Continued

Table II *(Continued)*. Details about the 48 YouTube videos, discussing pharmacokinetics, identified in the study.

No	Title	URL	Duration Min (Sec)	Viewers	Days on YouTube	Viewership/ day	Total score* mean ± SD
26	259 FA 12 : Pharmacokinetics equations with examples	http://youtu.be/Cz3MteKFGYM	05 (28)	1.076	357	3.01	13.33 ± 0.57
27	259 FA 12: Pharmacokinetics equations part	http://youtu.be/uQL_uQdH19g	04 (24)	816	357	2.28	13.33 ± 0.57
28	Pharmacokinetics: Analyzing Concentration Data (Bio)	http://youtu.be/zWcm_Z0Dm_s	06 (35)	1.153	711	1.62	13.67 ± 0.57
29	Zero order elimination rate	http://youtu.be/orGqn49MMXY	09 (30)	5042	758	6.65	13.33 ± 0.57
30	Introduction to Pharmacokinetics	http://youtu.be/mp93nPUzHqM	10 (52)	87.146	1021	85.35	13.67 ± 0.57
31	Pharmacokinetics; Absorption & Distribution by Professor Fink	http://youtu.be/2MKjLFbD_Zg	40 (49)	3.825	159	24.05	7.67 ± 0.57
32	Pharmacokinetics: Vd. Clearance. Half-life: Calculation Drug Distributi	http://youtu.be/ItjPn8WxVSA	02 (15)	4.982	215	23.17	5.33 ± 1.15
33	Pharmacokinetics & Half Life Simple! "ADME"	http://youtu.be/1e1xwgEwqAc	09 (36)	1.560	260	6.00	4.67 ± 0.57
34	Pharmacokinetics and Pharmacodynamics	http://youtu.be/0EHR7cSgdvY	11 (29)	523	372	1.40	4.67 ± 0.57
35	PharmaPendium for drug development decisions: Pharmacokinetics w	http://youtu.be/MV4QiwqeT6w	40 (05)	206	518	0.39	6.67 ± 0.57
36	Alcohol pharmacokinetics	http://youtu.be/zy81Tr9wD24	01 (18)	533	1016	0.52	5.33 ± 1.15
37	3GPH Biopharmaceutics and Pharmacokinetics	http://youtu.be/KiU_39XQJMM	03 (48)	3.517	1467	2.39	3.33 ± 0.57
38	Pharmacokinetics Example (Dosing a Patient)	http://youtu.be/DJ4dho7Exb0	05 (18)	2.035	712	4.26	7.67 ± 0.57
39	Pharmacokinetics and Pharmacodynamics with Steven Rottman PhD (2)	http://youtu.be/IMVHRAkG3Jw	27 (17)	33	134	0.24	4.67 ± 1.15
40	Pharmacokinetics: Important pharmacokinetic terms	http://youtu.be/veNA5VNEwqc	0 (27)	03	18	0.16	6.67 ± 0.57
41	Pharmacokinetics	http://youtu.be/p47rdwqu6GI	1 (29)	01	207	0.004	6.67 ± 0.57
42	Drug pharmokinetic absorbtion and metabolism	http://youtu.be/D1XAkcsAYKk	0 (15)	597	753	0.79	5.67 ± 0.57
43	Pharmacokinetics Made Simple	http://youtu.be/aIRCp38AypI	53 (30)	1.966	101	19.46	9.67 ± 2.30
44	1 2 - 1. Introduction to Pharmacokinetics	http://youtu.be/Qnxxr2HffBc	23 (04)	746	190	3.92	8.67 ± 0.57
45	Pharmacokinetics Part 1	http://youtu.be/dvJvct36JGE	27 (32)	6	22	0.27	7.33 ± 1.15
46	Pharmacokinetics Part 2	http://youtu.be/-u3UZ0Uv4hA	13 (45)	5	22	0.27	7.67 ± 0.57
47	Pharmacokinetics Part 3	http://youtu.be/mYXrUplVtwU	27 (35)	4	22	0.18	7.67 ± 0.57
48	Quick Pharmacokinetic Review	http://youtu.be/2zN74QZC5rA	06 (11)	142	190	0.74	7.67 ± 0.57

Educationally useful videos on pharmacokinetics (1 to 30, n=30). Non-educationally useful videos on pharmacokinetics (31 to 48 n= 18). *Total score (mean ± SD) calculated from the scores given by three evaluators to each video.

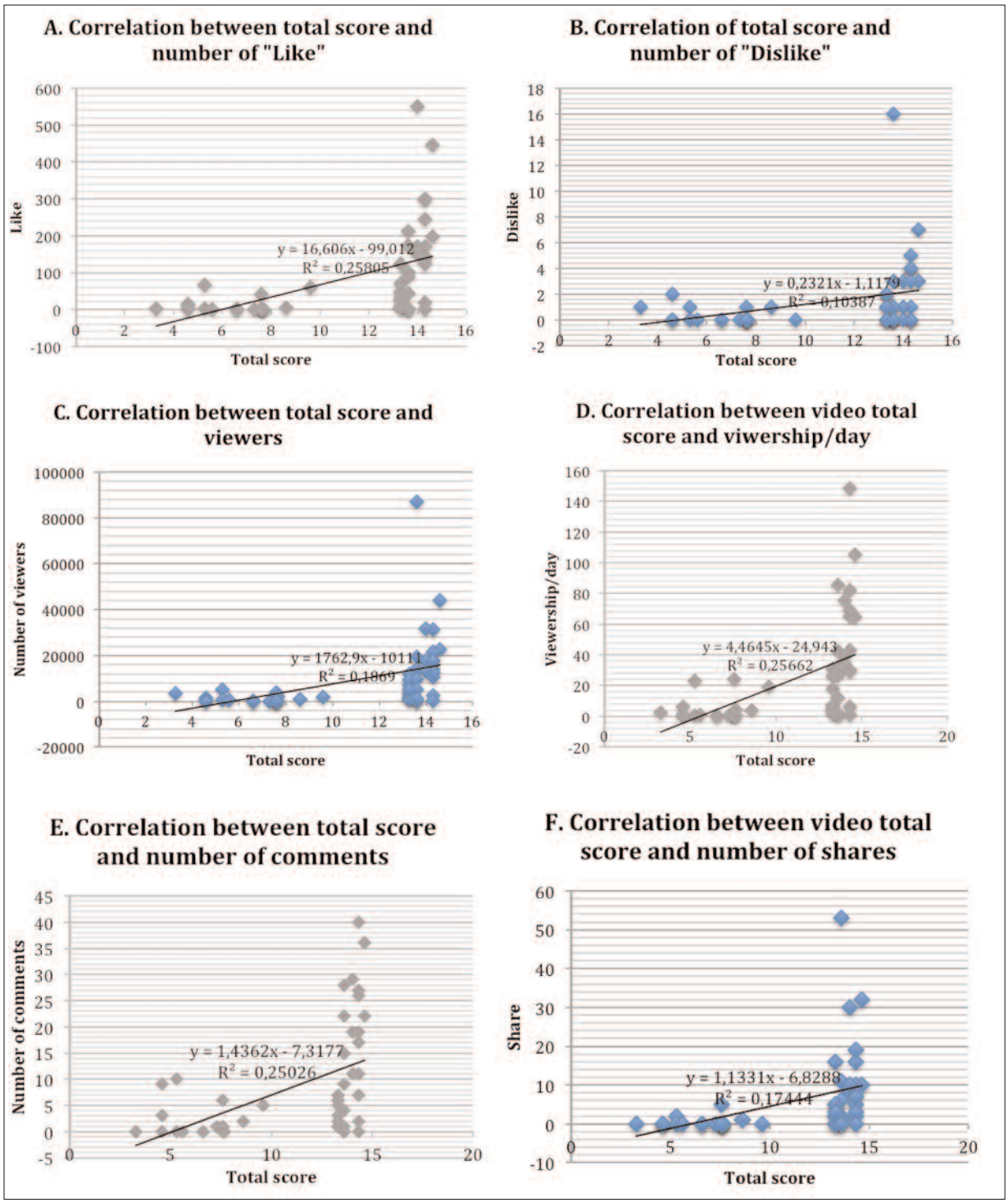

Figure 2. ***A-F,*** Correlation between video total score and engagement.

by students anywhere on the globe. This educational responsibility is particularly important with current changes in medical education and the changes in the priorities of students in their selection of their learning resources[33].

Much emphasis has been placed on pharmacokinetics in basic and clinical pharmacology in current medical curricula[5,34-36]. To learn such skills, students usually relay on textbooks, websites and lectures. However, understanding diffi-

Table III. Overall agreement between the three evaluators using the criteria.

Item number	Item*	Mean scores (minimum and maximum)			Evaluator variability (kappa range)
		Evaluator 1	Evaluator 2	Evaluator 3	
1.	The videos use clear graphs and or illustrations to explain topics	1.54 (0.00-2.00)	1.54 (0.00-2.00)	1.50 (0.00-2.00)	0.943-1.000
2.	Contents about pharmacokinetics are scientifically correct.	1.75 (0.00-2.00)	1.75 (0.00-2.00)	1.71 (0.00-2.00)	0.911-1.00
3.	The images are clear	1.54 (0.00-2.00)	1.54 (0.00-2.00)	1.50 (0.00-2.00)	0.943-1.00
4.	The topic is clearly presented, engaging and enforces understanding.	1.29 (0.00-2.00)	1.25 (0.00-2.00)	1.29 (0.00-2.00)	0.955-1.00
5.	Sounds are clear, no noises in the background.	1.58 (0.00-2.00)	1.54 (0.00-2.00)	1.50 (0.00-2.00)	0.939-1.00
6.	Minor The videos cover the topic identified the title.	0.90 (0.00-1.00)	0.92 (0.00-1.00)	0.81 (0.00-1.00)	0.565-0.878
7.	The video is designed at the level of undergraduate students.	0.77 (0.00-1.00)	0.83 (0.00-1.00)	0.67 (0.00-1.00)	0.441-0.804
8.	Time to download is reasonable	0.96 (0.00-1.00)	0.98 (0.00-1.00)	0.92 (0.00-2.00)	0.291-0.594
9.	The educational objectives. are stated	0.33 (0.00-1.00)	0.27 (0.00-1.00)	0.38 (0.00-1.00	0.582-0.656
10.	The creator/organization is mentioned	0.50 (0.00-1.00)	0.50 (0.00-1.00)	0.71 (0.00-1.00)	0.417-0.917

*Items 1-5 represent major criteria, and items 6-10 represent minor criteria used. The maximum score is 15.

cult concepts and application of principles learnt to real life situations may not be enabled through reading texts. Learning about pharmacokinetics' calculations and applying principles necessitates deep understanding and explanations that textbooks and possibly some lecturers may not be able to provide. Educationally useful well-designed videos, on the other hand, could fill this gap and enable understanding. Add to this the advantages inherit in YouTube videos, namely, being free of charge, can be replayed as needed, and all the users need is a connecting their computer or mobile phone with the Internet. Online videos have become a routine and important tool in student's learning. Attending lectures, reading textbooks along with watching online videos and applying skills learnt is an important learning strategy that have been used by medical students.

While the current move by the learners is in favor of the use of Internet as their primary source of information, it is important that medical educators recognize the significance of YouTube in the learning and teaching and sharing the responsibility in developing resources that can be uploaded and shared on YouTube[21,37].

Although there are other websites providing free videos such as Pharmacology Corner (pharmacologycorner.com); and Principles of clinical pharmacology provided by NIH Clinical Center (pcp.nihtraining.com), it was decided to include YouTube videos solely in this study for a number of reasons: First, YouTube website is popular, preferred by users[38]. and is easily to find compared to other websites; Second: YouTube provides an extensive variety of videos with approximately 100 hours of video are uploaded to YouTube every minute[39-40]; giving more opportunities for users to find the videos they are searching for; Third, YouTube introduces continuous improvement to its website. Recently, YouTube launched YouTube EDU, an area of YouTube dedicated to high quality credentials. Such move may have a major impact to the uses and uploaders and is likely to be a useful source for scholarly videos.

The criteria used in this study are simple, easy to apply and are based on four parameters including technical, content, authority and pedagogy components. The agreement among evaluators had an overall Cohen's kappa score in the range of 0.582 to 0.949.

Limitations

The study covers a snapshot of videos available on YouTube during 1 November to 15 November 2013, however, it is expected that more

videos are uploaded and added to this area. Considering the continuing increases in the number of videos uploaded on YouTube on daily basis, it is difficult to make a final conclusion about the status of YouTube in this area. However, there is a need for future research to assess whether there has been high quality videos covering deficiencies identified have been added to YouTube and more educationally useful videos on pharmacokinetics are available to learners. Another limitation is the small number of videos included in the study and the limitation of the study on videos in the English language. Also this study was limited to videos on YouTube website and there is the possibility that more videos on medical and pharmacology and toxicology societies' websites were not included.

Conclusions

The data presented in this study suggest that overall the most easily accessible or watched YouTube videos on pharmacokinetics are not necessarily educationally robust or scientifically correct. Although a few videos had high scores as per the criteria used and were educationally useful, other videos were not fulfilling the inclusion criteria and were of limited educational value. They were not that different from textbooks and did not effectively use the inherit capacities that can enable the learners' deep understanding. Considering the tendency of medical students to depend on YouTube videos in their learning, it may be necessary to train students on how to use guidelines such as the criteria used in this study in evaluating videos to identify educationally useful videos. Also it is clear from this study that users who rely on the comments made by viewers or the approval expressed in terms of the number of "like" given by viewers should become aware that these indicators are not accurate and they do not correlate with the scores given to videos. Given the expectation of medical educators and medical teachers that students should take responsibilities of their self-regulated learning and the learning resources they use, there is a need for YouTube to provide rigorous evaluation of videos and identify educationally useful videos. This recommendation together with the need of medical schools to offer training to its students on how to select their online resources such as educationally useful videos on YouTube is necessary.

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Conflict of Interest

The Authors declare that there are no conflicts of interest.

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