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Observational Study

- 1 Pandemic and precocious puberty - a Google trends study

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Observational Study

Pandemic and precocious puberty - a Google trends study

Athanasios Tselebis, Lina Zabuliene, Charalampos Milionis, Ioannis Ilias

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Recent publications from several countries have reported that more young people (mainly girls) are experiencing precocious puberty (PP)/menarche during the coronavirus disease 2019 pandemic compared to the past. This variation is attributed to the stress of confinement, lack of exercise, obesity and disturbed sleep patterns. A common feature of the relevant papers, however, is the small number of reported cases of PP. Studies have shown that searches for diseases on the internet also reflect to some extent the epidemiology of these diseases.

AIM

To estimate, through internet searches for PP, any changes in the epidemiology of PP.

METHODS

We assessed in Google Trends searches for 21 PP-related terms in English internationally (which practically dwarf searches in other languages), in the years 2017-2021. Additionally, we assessed local searches for selected terms, in English and local languages, in countries where a rise in PP has been reported. Searches were collected in Relative Search Volumes format and analyzed using Kendall's Tau test, with a statistical significance threshold of $P < 0.05$.

RESULTS

Internationally, searches for three PP-related terms showed no noticeable change over the study period, while searches for eight terms showed a decrease. An increase was found over time in searches for nine PP-related terms. Of the 17 searches in English and local languages, in countries where a rise in PP has been reported, 5 showed a significant increase over time.

CONCLUSION

Over the study period, more than half of the search terms showed little change or declined. The discrepancy between internet searches for PP and the reported increase in the literature is striking. It would be expected that a true increase in the incidence of PP would also be aptly reflected in Google trends. If our findings are valid, the literature may have been biased. The known secular trend of decreasing age of puberty may also have played a role.

Key Words: Data collection; Epidemiology; Puberty; Human; Methods; Trends

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Core Tip: An increasing number of young people are experiencing precocious puberty (PP) during the coronavirus disease 2019 pandemic. We estimated, through relevant internet searches, changes in the epidemiology of PP. We assessed in Google trends searches for PP-related terms in English internationally, and in English and local languages, in countries where a rise in PP has been reported, in the years 2017-2021. More than half of the search terms showed little change or declined. The discrepancy between internet searches for PP and the reported increase in the literature is striking. If our findings are valid, the literature may have been biased.

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INTRODUCTION

Precocious puberty (PP) describes the changes associated with the transition to adult body habitus earlier than age 8 in girls and age 9 in boys. Children with PP may have a short final height, suffer from poor body image, low self-esteem, depression and anxiety and/or be plagued by problems in socialization (particularly with peers), sexuality and substance abuse[1].

Recent publications from several countries[2-5] have reported that more young people[6-10] (mainly girls) are experiencing PP/menarche during the coronavirus disease 2019 (COVID-19) pandemic compared to the past[11-13]. This variation is attributed to the stress of confinement, lack of exercise, obesity, and disturbed sleep patterns. A common feature of the relevant papers, however, is the small number of reported cases of PP, with the exception of reports from South Korea (see below). Among adult internet users who look for specific health issues, approximately one in four has read or watched someone else's health experiences or medical issues in the last year; and one in six is seeking others with the same health concerns[14]. These behaviors are more prominent in caregivers and patients with chronic diseases[14]. Digital epidemiology uses digital data that were not generated with the primary goal of serving epidemiological research[15]; such data are within the domain of "infodemiology"[16]. Studies have shown that searches for diseases on the internet also reflect to some extent the epidemiology of these diseases. Google trends (available at <https://trends.google.com>) provides free access to search requests made to Google. The data are amassed *via* sampling algorithms proprietary to Google and are anonymized and categorized. Searches on the Internet may - according to some researchers - accurately reflect the epidemiology[16-18] of infectious[19-23], acute[24], or chronic[25] diseases, including, among others, coronary[24] or thyroid disease[19,25]. The use of Google trends, with the aim to study a wide range of medical topics, is becoming more widespread. In this work, we assessed the reported increased incidence of PP from the perspective of digital epidemiology, since the latter may be a useful adjunct to classical epidemiology.

MATERIALS AND METHODS

Data collection

We collected from Google trends (<https://trends.google.com>), the searches for 21 PP-related keywords/search terms in English internationally. We chose keywords/search terms in English because in previous studies we showed that with regards to Google trends, the volume of internet searches in English is vastly larger than in any other language (and practically dwarfs searches in other languages [18]). We limited the collection to the years 2017-2021 (Table 1). The years of the study were imposed by

Table 1 Worldwide searches in English for precocious puberty-related terms vs time

Search terms	Tau (P value)
Puberty-related terms <i>per se</i>	
"Puberty"	+0.351 (< 0.001)
"Precocious puberty"	+0.048 (0.250)
"Early puberty"	+0.130 (< 0.001)
Body-related terms	
"Hair"	+0.114 (0.008)
"Pubic"	-0.567 (< 0.001)
"Pubic hair"	-0.499 (< 0.001)
"Axillary"	+0.254 (< 0.001)
"Axillary hair"	+0.146, (< 0.001)
"Height"	+0.713 (< 0.001)
Female body-related terms	
"Breast"	-0.219 (< 0.001)
"Breast enlargement"	-0.497 (< 0.001)
Menstruation-related terms	
"Menarche"	+0.125 (0.003)
"Menses"	-0.556 (< 0.001)
"Period"	+0.584 (< 0.001)
Male body-related terms	
"Testes"	+0.119 (0.004)
"Testicles"	-0.506 (< 0.001)
"Testicular enlargement"	+0.024 (0.601)
"Penis"	-0.726 (< 0.001)
"Penis growth"	-0.226 (< 0.001)
"Scrotum"	-0.262 (< 0.001)
"Scrotum growth"	-0.006 (0.881)

Google Trends' algorithms: These were changed, according to Google, on January 1, 2017 and then on January 1, 2022. The PubMed database (<https://pubmed.ncbi.nlm.nih.gov/>) was searched, with no time limits. The search strategy, honed on the tentative effects of COVID-19 on PP, was as follows: "((precocious AND puberty) OR (early AND puberty)) AND COVID-19". There were 12 original articles (not case reports), all of which[5-8] reported a rise in PP cases[9-12] during the pandemic[13]. Additionally, we assessed Google trends local searches for selected terms, in English and local languages, in countries where a rise in PP has been reported in the medical literature (Table 2). Google does not report absolute internet search volumes. Instead, Google gives the sum of each search in the form of relative search volumes (RSVs)[26]. These RSVs are percentages relative to the peak search volume obtained during the specified time period and scaled by the total search volume for each specific search term. Consequently, these numbers do not represent absolute search volume numbers, but are normalized and presented on a scale from 0 to 100[26].

Data analyses

The collected searches (in RSV format) per each week were assessed vis-à-vis time (in weeks) and analyzed using Kendall's Tau test, with a statistical significance threshold of $P < 0.05$, using JASP v.0.16.3 (JASP Team, University of Amsterdam, Netherlands, 2022).

Table 2 Selected searches in English and local languages in countries where a rise in the reporting of precocious puberty has been reported vs time

Search terms	Tau (P value)
Italy (English & Italian)	
"Precocious Puberty"	NA
"Pubertà Precoce"	+0.046 (0.292)
"Early puberty"	NA
"Menarche"	NA
"Menarca"	+0.057 (0.169)
Turkey (English & Turkish)	
"Precocious Puberty"	NA
"Erken Ergenlik"	+0.050 (0.248)
"Early puberty"	NA
"Menarche"	NA
"Menarş"	+0.002 (0.996)
India (English, Marathi & Hindi)	
"Precocious Puberty"	+0.103 (0.014)
"Precocious Puberty (in Marathi)"	+0.118 (0.004)
"Precocious Puberty (in Hindi)"	NA
"Early puberty"	+0.052 (0.240)
"Menarche"	+0.371 (< 0.001)
"Menarche (in Marathi)"	NA
"Menarche (in Hindi)"	+0.041 (0.161)
Brazil (English & Portuguese)	
"Precocious Puberty"	NA
"Puberdade Precoce"	+0.362 (< 0.001)
"Early puberty"	NA
"Menarche"	+0.002 (0.959)
"Menarca"	+0.264 (< 0.001)
Spain (English & Spanish)	
"Precocious Puberty"	NA
"Pubertad precoz"	-0.007 (0.862)
"Early puberty"	NA
"Menarche"	-0.006 (0.904)
"Menarquia"	+0.038 (0.356)
South Korea (English & Korean)	
"Precocious Puberty"	-0.008 (0.427)
"Precocious Puberty (in Korean)"	NA
"Menarche"	0.012 (0.397)
"Menarche (in Korean)"	0.011 (0.395)

NA: Not available.

RESULTS

In the published reports of increased PP during COVID-19, in 2020, the reported cases were relatively disproportionally distributed, with 678 cases in Italy[2-6], 275 in Turkey[8-10], 237 in China[11], 22 in Brazil[12] and 155 in India[13]; Portugal was not included in further analyses (see below for details). In South Korea, with data obtained from the country's hospital records/healthcare database, 95524 children were diagnosed with PP in 2017 (9.89% boys), increasing over the years to 166645 children in 2021 (19.55% boys). These corresponded to 0.18% of South Koreans in 2017 to 0.32% of South Koreans in 2021[27].

Internationally, searches for three PP-related terms in English showed no noticeable change over the study period, while searches for eight terms showed a decrease. An increase was found over time in searches for nine PP-related terms (Table 1 and Figure 1). Of the 18 searches in English and local languages, in countries where a rise in PP has been reported, only 5 showed a significant increase over time (Table 2). In South Korea the reported total yearly numbers of PP cases has more than doubled over a timespan of 6 years; this increase is not mirrored by relevant internet searches. No searches were done for Portugal, since the only publication from this country, states - in a counterintuitive way - that there was an increase of PP cases at a single center, albeit with 598 cases in 2019 *vs* 471 cases in 2020[7]. Additionally, no searches were done for China (see the limitations section below). All the search data used are available online at: <https://doi.org/10.5281/zenodo.7152041>.

DISCUSSION

Over the study period more than half of the search terms showed little change or declined. Apparently, the most accurate and complete exposé of an increase in PP comes from South Korea. In this country, the reported total yearly numbers of PP cases has more than doubled over a timespan of 6 years[27]. Yet, this increase is not mirrored by relevant internet searches. The discrepancy between internet searches for PP and the reported increase in the literature is striking. The epidemiology of acute diseases (like influenza[19-23]) or chronic diseases (like thyroid[19,25] or cardiovascular ailments[24]) has been shown over the years to be reflected in associated and relevant internet searches, as they are gathered, summarized and reported in Google trends[16-18]. Lending credence to the association between disease cases and internet searches, in 2020-2021, the officially reported cases of COVID-19 worldwide were positively associated with relevant Google trends searches, as it has been shown in research works by our group as well by the work of other researchers[19,28,29]. In an analogous way, it would be expected that a true increase in the incidence of PP would also be aptly reflected in Google trends. If our findings are valid, then the literature is likely to show some bias and also to be distorted by the small - proportionally - number of reported PP cases.

For PP, its epidemiological profile is not clear worldwide, with vast differences across countries and continents, with some published reports in the medical literature presenting the incidence and others giving the prevalence of PP, adding to confusion[1]. The "gold standard" to help in the diagnosis/differential diagnosis of PP is the gonadotropin-releasing hormone test. It is laborious and costly. Tools using readily and easily available data may be handy in the diagnosis and eventual management of PP[30]. Additionally, there is a lack of validated instrument to assess the psychosocial impact of PP[31]. Internet-based tools could fill this gap.

The COVID-19 pandemic was an unprecedented event, with profound effects in social/psychological functioning[32], particularly during the lockdown periods; anxiety and interoception were affected[33]. Parents were very stressed during the early phases of the pandemic[34]. This could have also led to heightened vigilance and preoccupation with their children's welfare[35]. The provision of healthcare - at times - was greatly compromised. The referrals and diagnoses of PP under such circumstances may be prone to several biases[36,37]. The numbers of patients channeled to specialized centers may be prone to centripetal, diagnostic access and referral bias and the diagnoses at these centers may be prone to confirmation bias. Studies generated at these centers may be hampered by wrong size bias[38]. The known secular trend of decreasing age of puberty may also have played a role. Trends of increased PP incidence had been noted in Denmark[39] and Spain[40]. Regarding South Korea, the recent finding of increasing PP incidence is not novel[27]. A secular trend of increasing PP incidence had been also noted earlier, in the years 2004 to 2010 in the same country[41]. There are no clear causative factors for the reported rise in the incidence of PP. Excess sedentary lifestyle and rising obesity may play a role[42]. Thus, the epidemiology of PP is varied across different populations and countries; comparisons among them may not be straightforward.

There were limitations and caveats in our study. We collected only Google trends data, but as far as the internet is concerned, Google searches outnumber those of any other search engine, reaching an impressive percentage of 95% worldwide (<https://gs.statcounter.com/search-engine-market-share>; accessed October 30, 2022). An exception to this is China, where the internet is searched with local search engines, albeit without a feature analogous to that of Google trends. Moreover, we know that English-language searches outnumber searches in all other languages[18]. Another limitation was the

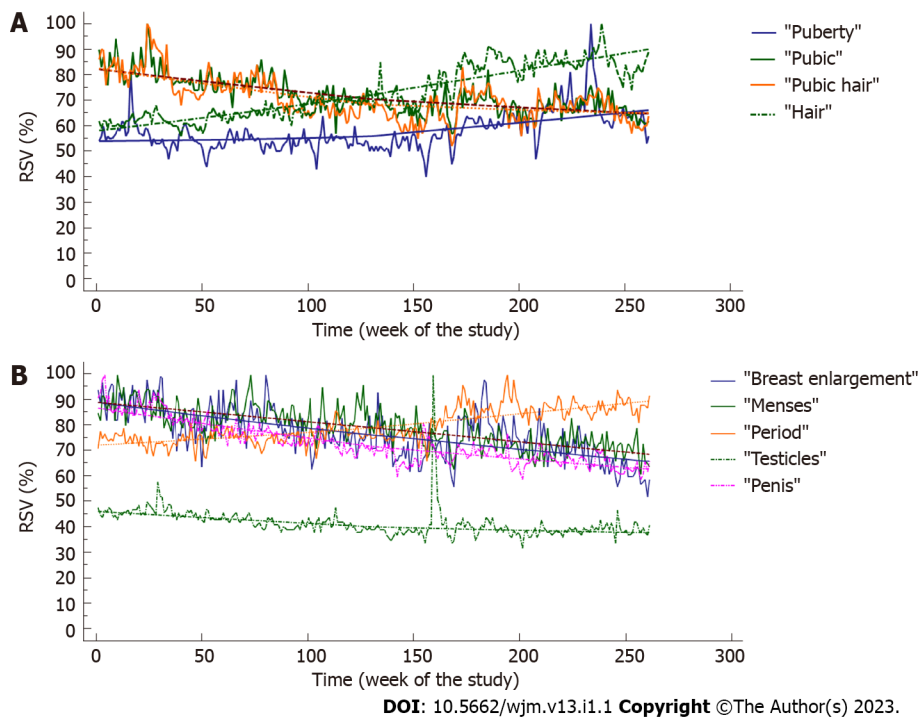


Figure 1 Selected Internet searches worldwide (as relative search volumes) for non-sex-specific and sex-specific terms related to premature puberty. A: Non-sex-specific terms; B: Sex-specific terms. RSVs: Relative search volumes.

restrained choice of keywords in the searches; for the sake of homogeneity in the searches, the “related queries” feature of Google trends was not used. We did not evaluate for any periodicity because of the relatively short duration of pandemic. Medical research articles generate public interest when reported by news outlets[43]; Google searches are easily influenced by media items[43]. For the duration of the study no such interest was discernible, since the relevant medical articles on increased incidence of PP appeared in 2022, after the end of this study’s time period.

CONCLUSION

The increase in the incidence of PP in the COVID-19 era, which is reported in the medical literature, is not fully reflected in internet searches. This is an evolving issue; hopefully further relevant studies will shed light on it.

ARTICLE HIGHLIGHTS

Research background

Recent publications from several countries have reported that more young people (mainly girls) are experiencing precocious puberty (PP)/menarche during the coronavirus disease 2019 (COVID-19) pandemic compared to the past. This variation is attributed to the stress of confinement, lack of exercise, obesity and disturbed sleep patterns. Studies have shown that searches for diseases on the internet also reflect to some extent the epidemiology of these diseases.

Research motivation

A common feature of the relevant papers on the rise of PP, however, is the relatively small number of reported cases. With this study we aimed to estimate, through internet searches for PP, any changes in the epidemiology of PP.

Research objectives

We assessed in Google trends searches for 21 PP-related terms in English internationally, in the years 2017-2021. Additionally, we assessed local searches for selected terms, in English and local languages, in countries where a rise in PP has been reported.

Research methods

Searches were collected in relative search volumes format and analyzed using Kendall's Tau test, with a statistical significance threshold of $P < 0.05$.

Research results

Internationally, searches for three PP-related terms showed no noticeable change over the study period, while searches for eight terms showed a decrease. An increase was found over time in searches for nine PP-related terms. Of the 17 searches in English and local languages, in countries where a rise in PP has been reported, 5 showed a significant increase over time.

Research conclusions

Over the study period, more than half of the search terms showed little change or declined. The discrepancy between internet searches for PP and the reported increase in the literature is striking. It would be expected that a true increase in the incidence of PP would also be aptly reflected in Google trends. If our findings are valid, then the literature may have been biased. The known secular trend of decreasing age of puberty may also have played a role.

Research perspectives

The increase in the incidence of PP in the COVID-19 era, which is reported in the medical literature, is not fully reflected in internet searches. This is an evolving issue; hopefully further relevant studies will shed light on it.

FOOTNOTES

Author contributions: All the authors have contributed to the collection of data and the drafting of the manuscript.

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