Mobile and Wearable Technologies for Persons with Disabilities: A Bibliometric Analysis (2000~2021)

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Purpose

This study uses a bibliometric approach to analyse the patterns in research related to mobile and wearable technologies for persons with disabilities to evaluate the current state of relevant research.

Materials and methods

A systematic search was done using two strings covering “disability” and “mobile and wearable technologies” in the titles of publications in the Web of Science database. Two researchers independently screened the results for relevant publications. During this process, the inclusion and exclusion criteria were deliberated and refined. An independent researcher checked the screening results against the finalized inclusion and exclusion criteria to ensure that the screening was done consistently.

Results

A total of 2012 out of the 5990 retrieved publications from 2000 to 2022 were included for further analysis. We observed that publications in this area grew exponentially since 2011, almost doubling every 2 years between 2011 and 2015. Universities in the USA were the most active and prominent in relevant publications. Autism is the most researched disability in relation to mobile and wearable technologies. The publications cover both hardware (engineering, electrical & electronic) and software (computer science, theory & methods) technologies used for improving quality of life for persons with disabilities (rehabilitation).

Conclusions

The majority of publications were from high income countries, indicating the need to study the digital divide among high-, low- and middle-income countries in adopting mobile and wearable technologies for persons with disabilities, especially ways of making these technologies more affordable and accessible to the under-privileged members of the community.

Keywords: mobile technologies; wearable technologies; disabilities; bibliometric

Implications for rehabilitation

- Mobile and wearable technologies as a more generic, available and affordable approach complementing more specialized assistive technologies for persons with disabilities.
- A bibliometric study illustrates the trend in research of mobile and wearable technologies for persons with disabilities, and of the relevant publications.
- Through this bibliometric study, rehabilitation practitioners can identify the key researchers, universities and countries contributing to relevant publications, for potential collaboration as well as implementation of rehabilitation solutions for persons with disabilities.
- The identified main journals and anchor publications in relevant fields of research allow rehabilitation researchers to focus on topics that have attracted much interest among the stakeholders as well as topics that are still under-researched, hence identifying gaps in research.

Introduction

According to the World Report on Disability [1], approximately 15% of the world population have a disability. Persons with disabilities face barriers to fully participate in society. These include physical barriers that prevent access to buildings and facilities; informational barriers that prevent access to information; and attitudinal barriers leading to discrimination which affects the rights of persons with disabilities [1]. The United Nations Convention on the Rights of Persons with Disabilities [2] outlines measures to remove barriers and promote their effective participation in society. The United Nations Sustainable Development Goals also ensure the inclusion and development of persons with disabilities [3].

Some of the barriers faced by persons with disabilities can be overcome to a certain extent by technology. Technology has the potential to enable persons with disabilities to be independent and participate fully in life. According to Article 4 1(g) of the United Nation's Convention on the Rights of Persons with Disabilities, States Parties should "undertake or promote research and development of, and to promote the availability and use of new technologies, including information and communications technologies, mobility aids, devices

and assistive technologies, suitable for persons with disabilities, giving priority to technologies at an affordable cost".

According to the World Health Organization [4], assistive technology is "an umbrella term covering the systems and services related to the delivery of assistive products and services". The aim of assistive products is to maintain or improve an individual's functioning an independence. Examples include hearing aids, wheelchair, communication aids, and memory aids. Technology for persons with disabilities has been used in various aspects of life including education [5], employment [6], and healthcare [7]. Technology has also been used in different settings for by persons with disabilities including home [8], school [5], and work [9].

Persons from various groups have benefitted from technology, including persons with intellectual disabilities, developmental disabilities, physical disability, and visual impairment. Technology has benefitted children as well as adults with disabilities. For children with disabilities, technology has been used to support play [10] and assisting in schoolwork [11]. For adults with disabilities, it has made them more independent. Technology may be used not only by persons with disabilities, but also by healthcare providers, community workers, and family members [1].

Mobile technology are handheld IT artefacts that encompass hardware (devices), software (interface, applications), and communication (network services) [12]. They fall into five categories, namely smartphones, tablets, smartwatches, consumer devices or connected healthcare devices [13]. Wearable technology, on the other hand, refers to a range of devices worn by a person or attached to clothing. Most of these devices are connected to the Internet. Data collected by the devices may be transferred through the network and/or data may be transmitted to the device over the network [14]. Examples of wearable technology include smartwatches, smartglasses, fitness trackers, virtual reality headsets, and sensor devices such as accelerometers.

With the increased penetration of mobile devices such as smartphones and tablets among the public, the advanced capabilities of these devices are being incorporated into assistive technologies [15]. These technologies has the potential to reduce barriers for persons with disabilities. The ongoing rollout of 5G also holds potential for many more features for mobile and wearable technologies to be used in assistive technology. In 2020, there were

826.6 million mobile cellular subscriptions and 60% of the world population used the Internet [16].

Despite the utilization of mobile and wearable technologies for persons with disabilities, there has been little study of overall trends in this area. Thus, this study uses a bibliometric approach to analyse the patterns in research related to mobile and wearable technologies for persons with disabilities to evaluate the current state of research. Bibliometrics is a quantitative analysis method that uses mathematical and statistical tools to measure the inter-relationships and impacts of publications within a given area of research. We believe this bibliometric study shall provide a macroscopic overview of large amounts of academic literature, and can also be used to efficiently identify influential studies, authors, journals, organizations, and countries over time in the relevant fields of research.

Materials and methods

We conducted a systematic search in the Web of Science database on December 3, 2021. While it is possible to cover multiple databases in one bibliometric analysis, we followed recommendation of Donthu et al. [17] to use only one database as different databases have their own format of bibliometric data; hence focusing on one appropriate database mitigates the need and potential human errors when consolidating formats of different databases into one single format. In addition, Web of Science was chosen as it provides rich citation data of large amount of scientific literature in various disciplines for in-depth bibliometric analysis.

Our search string included a combination of two separate strings to cover “disability” and “mobile and wearable technologies” published documents, with the Boolean Operator AND between them. We used the following search string on publication titles for “disability”:

disab* OR handicap* OR impair* OR paralys* OR disorder* OR “visual impairment*" OR "ocular impairment*" OR blind* OR "low vision" OR “vision disorder*” OR “sensory disability” or “sensory impairment” OR "hearing impairment*" OR "aural impairment*" OR "auditory impairment*" OR deaf* OR “hearing disorder*” OR "physical disability" OR "spinal cord injur*" OR parapleg* OR quadripleg* OR tetrapleg* OR dwarf* OR amputee* OR "muscular dystrophy" OR "spinal bifida" OR “movement disorder*” OR sclerosis OR "intellectual impairment*" OR "intellectual disab*" OR "learning disab*" OR autism OR "Down syndrome" OR Asperger OR dyslexia OR “attention deficit disorder” OR “attention

deficit hyperactivity disorder" or "ADHD" OR "motor disability" OR "cerebral palsy" OR "musculoskeletal disorder" or "musculoskeletal injur*" OR "developmental disability" OR "Mental dis*" OR "cognitive dis*" OR "cognitive impairment" OR "neurological dis*" OR "neurodegenerative dis*" OR "traumatic brain injur*" OR "brain injur*".

And for "mobile and wearable technologies", we used the following:

app OR "mobile application" OR "mobile health" OR mHealth OR smartphone OR phone OR smart OR smartglasses OR smartglass OR smartwatch OR headset OR "augmented reality" OR AR OR "virtual reality" OR VR OR wearable OR device OR sensor OR accelerometer OR pedometer OR tracker OR SMS OR "text message" OR wireless OR "global positioning system" OR GPS OR "personal digital assistant" OR PDA OR "internet of things" OR IoT OR "body area networks".

We extracted the research articles and proceedings papers published between 2000 and 2022, whereas review articles, proceedings papers with abstract only, book chapters and books were excluded from the systematic search. The search yielded 5990 results from a total of 8667 identified records, which were imported to an Excel sheet for further screening and analyses. We screened the imported documents by reading the title and abstract of each document to only include relevant results. Two researchers (TKC, UK) first independently screened results published between 2000-2016 (2804 records) and 2017-2022 (3186 records), respectively. For the 21 records that were undecided on whether to include or exclude, the researchers than deliberated on these records and clarified on the inclusion and exclusion criteria. When all the 5990 records had been screened at least once, an independent researcher (JYN) checked the results against the finalized inclusion and exclusion criteria. The independent researcher found that the screening was done consistently between the two other researchers.

In the screening process, we included publications that involved technologies (technological solutions) either directly for persons with disabilities; or indirectly for empowering caregivers or teachers or doctors of persons with disabilities (e.g., for doctors to assess, teachers to teach persons with disabilities). In particular, the included technologies are:

- Mobile technologies including
    - Smartphone and smartphone application;
    - Tablet and tablet application;
    - Personal digital assistant;
    - Short message service (SMS); and
- Wearable technologies including
    - Smartglasses;
    - Smartwatch;
    - Sensors such as inertia sensor, accelerometer, pedometer, and global positioning system (GPS);
    - Augmented reality/virtual reality (AR/VR) and headsets;
    - Wearable robotic; and
    - Body area network.
- software models for mobile and sensors technologies

On the other hand, we excluded:

- Study protocols;
- Studies that reported results of survey or database analysis;
- Secondary studies like systematic literature review;
- Studies on technologies for the prevention of disabilities, technologies for the detection of disabilities, devices and Internet of things (IoT), which did not contain sensor or mobile technologies; and
- Studies on implantable devices.

This resulted in 2012 publications in our dataset for further analysis and calculations, as depicted in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram shown in Figure 1. Bibliometric analyses were based on quantitative analytical method and trends, including citation, authorship and keywords analyses, and calculations to find the most prominent authors, universities, and countries that are presented and discussed in the following sections.

Results

Overall trend

There has been an increase in the number of publications related to mobile and wearable technology and disability through the years (see Figure 2). With less than 20 publications per year from 2000 to 2006, the number rose to at least 25 publications a year from 2007 onwards, it then rose to at least 100 publications a year from 2014 onwards. The highest number of publications (n=259) was recorded in 2018. Of the total of 2012 included publications, more than half were published after 2017.

The three publication types include article, proceedings paper and article; proceedings paper (indexed in both databases for journals and proceedings). In total, there were 1075 articles, 900 proceedings papers, and 37 classified as both articles and proceedings papers.

Citation analysis

The top 10 most cited publications are presented in Table 1. They were published between 2005 and 2016. The top-cited publication was “Virtual reality social cognition training for children with high functioning autism” with 254 citations. Noteworthy here are “Virtual reality social cognition training for children with high functioning autism”, “Virtual reality–induced cortical reorganization and associated locomotor recovery in chronic stroke: An experimenter-blind randomized study”, and “Gait event detection using linear accelerometers or angular velocity transducers in able-bodied and spinal-cord injured individuals”, all with over 200 citations. Overall, the total citation was 21002 for the 2012 papers, and the average citation per paper was 10.44. Among the papers, 1493 (74.2%) received citation counts below 11. The mode and median citation counts are 0 and 3, respectively.

Authors and affiliations

A total of 8056 authors from 83 countries contributed to the publications. In total, the 2012 included publications were contributed by 1000 universities/institutions around the world.

In Table 2, we list the top 10 universities/institutions with the highest publications and citations. The top 10 universities/institutions by publication contributed a total of 180 publications, which accounted for 8.95% of the total publications. The University of Toronto (Canada) contributed the highest number of publications (n = 24). On the other hand, based on the number of times cited, Yeungnam University (Korea) is the most influential university/institutions, with a total of 661 citations. Out of the top 10 universities/institutions by citation, 5 are in the USA, 2 in South Korea and Canada, and 1 in Israel.

It is also important to note that Table 2 ranks the universities by citation count and not by number of publications associated with a university. For example, there are other Korean universities that published more than Yeungnam University (4 publications) but not listed in Table 2 as their publications did not accumulate as many citations as Yuengnam University. These include Seoul National University with 7 publications (41 citations) and Sung Kyun Kwan University with 7 publications (380 citations) but both do not make it among the top 10 universities by citation count.

In Table 3, we list the top 10 authors based on the number of publications and citations. The top 10 authors by publication published between13 and 17 articles. These authors contributed a total of 144 publications, which accounted for 7.16% of the total publications. The most prolific author with the highest number of publications is Zachary Warren with 17 publications. Furthermore, citations for the top 10 most cited authors ranged from 289 to 566. The most influential author with the highest number of citations is Patrice Weiss with 566 citations. Zachary Warren, who is the most prolific author with highest number of publications, is also included in this list. This indicates that Zachary Warren is both prolific and influential. Another notable author is Robert W. Motl with 14 publications and 436 citations. He ranks sixth in the list of top authors based on total publications, and fifth in the list of top authors based on total citations.

Our analyses of prolific authors and affiliations revealed that notable authors Zachary Warren and Nilanjan Sarkar were both affiliated with the Treatment and Research Institute for Autism Spectrum Disorders, Vanderbilt Kennedy Center (USA). Rajiv Dubey and Redwan Alqasemi were affiliated with Department of Mechanical Engineering, University of South Florida (USA). Among the influential authors, Nyaz Didehbani and Sandra B. Chapman were affiliated with the Center for BrainHealth, University of Texas at Dallas

(USA). Mark Hallet, Sung H. You, Sung Ho Jang, Yun-Hee Kim, and Yong-Hyun Kwon were affiliated with Hampton University (USA), although Sung Ho Jang was also reported to be affiliated with Yeungnam University (Korea) and Mark Hallet was affiliated with the National Institute of Neurological Disorders and Stroke, Human Motor Control Section, Bethesda (USA) in one of the articles. We produced a network map of co-authorship, but the network is small and the results were not meaningful, as depicted in Figure 3.

In Table 4, we list the top 10 countries based on the number of publications, which ranged from 73 to 573. These countries contributed a total of 1510 publications, which accounted for 75% of the total publications. USA was the country with the highest number of publications (n=573). Table 4 also lists the top 10 countries based on the number of times cited, which ranged from 967 to 8498. The most influential country with the highest number of citations is USA with 8498 citations. Another notable country is Italy which ranked second by both number of publications (n=188) and citations (n=1923).

Authors' keywords analysis

We conducted an analysis of the keywords authors used with their publications from 2000 to 2021. Table 5 lists the keywords that emerged from this analysis. The list in Table 5 indicates a number of keywords that refer to the type of mobile and wearable technology or the type of disability.

There are 7 keywords which refers to the type of mobile and wearable technology: virtual reality, augmented reality, assistive technology, accessibility, smartphone, computer mouse, and multimedia. Noteworthy here are virtual reality with the highest frequency of use (336) and augmented reality (104) with the second highest frequency.

There are six disability-related keywords: autism, rehabilitation, multiple sclerosis, cerebral palsy, autism spectrum disorder, and visually impaired. Prominent among these six keywords in terms of frequency of use are autism (98), rehabilitation (96), multiple sclerosis (89), and cerebral palsy (76). Also, it should be noted that both autism and autism spectrum disorder essentially refer to the same disability.

To indicate the trends across the 20-year period studies, we conducted a keyword analysis of each 5-year period from 2000 to 2021. The trends are presented in Table 6. The

temporal evolution of trends over the four 5-year period shows that virtual reality was the most frequently used keyword from 2005 to 2021. Virtual reality, rehabilitation, and multiple sclerosis have been among the most used keywords from 2005 to 2021, whereas augmented reality, autism, and cerebral palsy have been prominent from 2010 to 2021. Assistive technology was one of the most frequently used keyword from the years 2005 to 2009 and 2015 to 2021.

Types of technology and disability categories

We conducted analysis to categorize the identified publications into different types of technologies and disabilities. Table 7 shows the top 10 categories based on the number of publications. Seven categories in the top 10 list are related to technologies, however, only three are implicitly related to disabilities: rehabilitation, clinical neurology, and neurosciences. Engineering, electrical & electronic tops the list of the seven technology-related categories with a total of 448 publications, whereas rehabilitation has the highest number of publications (n=326) among the other three categories.

The categories that are related to the types of technologies contributed a total of 1725 publications, which accounted for 85.7% of the total 2012 publications, whereas the categories that are related to disabilities contributed a total of 600 publications, which accounted for 29.8% of the total publications. Also, it should be noted that many publications are multidisciplinary so they may be grouped into multiple categories.

We also investigated the trend of popular technologies by analysing frequencies of these technologies appearing as keywords of the selected publications on 5-year intervals. We noticed that different forms of spelling and aliases of the technologies were used in the publications, such as:

- Virtual reality, VR, virtual reality (VR), virtual reality technology, and virtual-reality; or
- Mobile application, mobile applications, mobile application (APP), mobile app, mobile apps, mobile phone application, mobile phone-based application, mobile device application, phone application, smartphone app, smartphone application, and smartphone apps.

Therefore, we grouped relevant variations of spelling and aliases in the keywords of the selected publications to show the technology trends as illustrated in Figure 4.

The top 6 technologies with at least 50 frequency count are virtual reality, augmented reality, smartphone, mobile application, wearable and accelerometer. Virtual reality has been the focal technology since 2000~2004 and shows about a five-fold increment between 2010~2014 and 2015~2021. In fact, drastic increments are seen for other technologies as well between 2010~2014 and 2015~2021, with mobile application showing the greatest increment of nearly 2800%. Wearable device, on the other hand, increased by some 1900% between these two periods. Thus, the last decade can be described as the "booming period" of mobile and wearable technologies for persons with disabilities.

The top 10 most cited journals are presented in Table 8. The top-cited journal was the *Journal of Autism and Developmental Disorders* with 875 citations. Noteworthy there are the *Journal of Autism and Developmental Disorders*, *Gait & Posture*, *Research in Developmental Disabilities*, and *Archives of Physical Medicine and Rehabilitation*, each with more than 500 citations.

Discussion

The presented bibliometric analysis of publications related to disabilities and mobile and wearable technologies during the last 20-year period revealed that the total number of publications steadily increased during this period. We observed that publications in this area grew exponentially from 2011, almost doubling every two years between 2011 and 2015. We attributed this growth to the rapid development of mobile technologies since 2007, such as the launch of the iPhone in 2007 and the first commercial version of Android in 2008; and the first prototype of the Oculus Rift VR headset in 2010. According to the International Telecommunication Union (ITU), the number of Internet users grew from 413 million in 2000 crossing 1 billion in 2005 in just five years and reached almost 5 billion in 2020 [28]. This enabled more widespread adoption of smart mobile and remote monitoring devices. Moreover, devices and sensors became available at cheaper rates during that period [29]. These developments attracted much research interest in applying mobile and wearable technologies for persons with disabilities.

When the number of publications peaked in 2018 (n=258), it was 11 times more than in 2008 (n=25). Since 2018, there were more than 200 articles published yearly, until it

dropped below 200 again in 2021 (n=197). Nevertheless, we take note that some articles published in 2021 have not been indexed in Web of Science yet when the bibliometric search was carried out in early December 2021. Thus, the actual number of publications in 2021 is likely to be more than 197. The 1355 articles published between 2018 and 2021 constitute 67.3% of the 2012 articles studied in this paper. One of the most common disabilities that was dealt with is autism. This may be attributed to the rise in the number of autism cases worldwide, as there are approximately 1 in 100 children diagnosed with autism spectrum disorder around the world, and the prevalence estimates increased over time [30].This is in-line with our findings, where in our keyword analysis, autism was the most used keyword and the *Journal of Autism and Developmental Disorders* was the journal with most citations.

Engineering, electrical & electronic; rehabilitation; computer science, theory & methods are the top-3 Web of Science categories in which the articles were published, with more than 300 publications each. From these categories of publications, we concluded that the publications covered both hardware (engineering, electrical & electronic) and software (computer science, theory & methods) technologies used for improving quality of life for persons with disabilities (rehabilitation). Rehabilitation is also one of the main keywords (ranked 4th with a frequency of 96). Among the top-10 journals based on citation counts, 3 have "rehabilitation" in their names, i.e., *Archives of Physical Medicine and Rehabilitation*, *Journal of Neuroengineering and Rehabilitation*, and *IEEE Transactions on Neural Systems and Rehabilitation Engineering*. Based on the analyses, we believe that mobile and wearable technologies can potentially provide evidence-based rehabilitation solutions for persons with disabilities. A promising trend we observed through the analyses is that assistive technology, accessibility, and smartphone emerged were frequently used keywords between 2015 and 2021 compared to previous years, indicating attempts of adopting more generic technologies (smartphones) for the wellbeing of people with disabilities, while assistive technologies and accessibility issues are gaining attention among the research community.

Geographically, universities in the USA are most active and prominent in the included publications, while universities in Canada, Korea, Israel, Brazil and Italy are also among the top-10 lists based on total publications and total citations. Ranked by countries, the USA still leads in both lists of total publications and total citations, followed by Italy, Spain, China, England, South Korea, India, Taiwan, Japan, Canada, Switzerland, and Israel. The majority of publications are from high-income countries, indicating the need to study the digital divide

among high-, low- and middle-income countries in adopting mobile and wearable technologies for persons with disabilities, especially ways of making these technologies more affordable and accessible to the under-privileged members of the community.

Conclusion

The paper is the first bibliometric analysis that investigates trends in mobile and wearable technologies for people with disabilities through analysing statistics of relevant publications in the Web of Science database. The number of publications increased in-line with the increasing popularity, availability and affordability of mobile and wearable technologies. One of the ways to make mobile and wearable technologies into more accessible and affordable assistive technologies is by leveraging on cheaper generic technologies, e.g., smartphones, for more targeted purposes, and rehabilitation of people with disabilities. This goal warrants further research in mobile and wearable technologies for persons with disabilities.

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Disclosure of Interest

The authors report no conflict of interest.

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Table 1. Top cited publications based on total citations.

	Publication	Total citations
1	Virtual Reality Social Cognition Training for children with high functioning autism [18]	254
2	Virtual Reality–Induced Cortical Reorganization and Associated Locomotor Recovery in Chronic Stroke An Experimenter-Blind Randomized Study. [19]	248
3	Gait event detection using linear accelerometers or angular velocity transducers in able-bodied and spinal-cord injured individuals. [20]	220
4	Feasibility, Motivation, and Selective Motor Control: Virtual Reality Compared to Conventional Home Exercise in Children with Cerebral Palsy. [21]	194
5	Body-worn motion sensors detect balance and gait deficits in people with multiple sclerosis who have normal walking speed. [22]	173
6	Cortical Reorganization and Associated Functional Motor Recovery After Virtual Reality in Patients With Chronic Stroke: An Experimenter-Blind Preliminary Study. [23]	165
7	Evaluation of a Body-Worn Sensor System to Measure Physical Activity in Older People With Impaired Function. [24]	160
8	Efficacy and safety of non-immersive virtual reality exercising in stroke rehabilitation (EVREST): A randomised, multicentre, single-blind, controlled trial. [25]	148
9	Using virtual reality to characterize episodic memory profiles in amnestic mild cognitive impairment and Alzheimer's disease: Influence of	137

	active and passive encoding. [26]	
10	In-Home Virtual Reality Videogame Tele rehabilitation in Adolescents with Hemiplegic Cerebral Palsy. [27]	134

Table 2. Top 10 universities/institutions based on total publications and citations. (n=1000)

Rank	By publication				By citation			
	University	**Country**	**Publication count**	**Citation count**	**University**	**Country**	**Citation count**	**Publication count**
1	University of Toronto	Canada	24	400	Yeungnam University	South Korea	661	4
2	University of Illinois	USA	23	528	University of Haifa	Israel	572	12
3	University of Washington	USA	20	418	University of Illinois	USA	528	23
4	Vanderbilt University	USA	20	389	University of Southern California	USA	475	10
5	University of Sao Paulo	Brazil	17	143	University of Texas at Dallas	USA	444	5
6	Politecnico di Milano	Italy	16	145	Vanderbilt University	USA	418	20
7	University of South Florida	USA	16	50	Yonsei University	South Korea	409	13
8	University of Bari Aldo Moro	Italy	15	177	University of Toronto	Canada	400	24
9	The University of Texas at Austin	USA	15	173	University of Ottawa	Canada	390	7
10	University of Pittsburgh	USA	14	116	University of Washington	USA	389	20

Table 3. Top 10 authors based on total publications and citations. (n=8056)

Rank	By publication			By citation		
	Author	**Publication count**	**Times cited**	**Author**	**Times cited**	**Publication count**
1	Warren, Zachary	17	289	Weiss, P	566	11
2	Sarkar, Nilanjan	15	269	Hallett, M	540	3
3	Lancioni, Giulio E.	15	174	You, SH	540	3
4	O'Reilly, Mark F.	15	174	Jang, SH	496	3
5	Lahiri, Uttama	15	165	Motl, RW	436	14
6	Motl, Robert W.	14	436	Didehbani, N	383	2
7	Sigafoos, Jeff	14	163	Kim, YH	375	2
8	Singh, Nirbhay N.	13	69	Kwon, YH	375	2
9	Dubey, Rajiv	13	44	Chapman, SB	296	3
10	Alqasemi, Redwan	13	37	Warren, Z	289	17

Table 4. Top 10 countries based on total publications and citations. (n=83)

Rank	By publication			By citation		
	Country	**Publication count**	**Times cited**	**Country**	**Times cited**	**Publication count**
1	USA	573	8498	USA	8498	573
2	Italy	188	1923	Italy	1923	188
3	Spain	127	1084	South Korea	1340	91
4	China	125	982	England	1276	95
5	England	95	1276	Canada	1224	73
6	South Korea	91	1340	Switzerland	1160	55
7	India	89	348	Spain	1084	127
8	Taiwan	75	989	Taiwan	989	75
9	Japan	74	348	China	982	125
10	Canada	73	1224	Israel	967	37

Table 5. Major keywords from 2000 to 2021. (n=4010)

	Keyword	Frequency
1	Virtual reality	336
2	Augmented reality	104
3	Autism	98
4	Rehabilitation	96
5	Multiple sclerosis	89
6	Cerebral palsy	76
7	Assistive technology	64
8	Autism Spectrum Disorder	63
9	Accessibility	57
10	Smartphone	55
11	Visually impaired	21
12	Physical activity	14
13	Walking	10
14	Computer mouse	3
15	Multimedia	2

Table 6. Temporal evolution of trends based on most frequently used keywords. (n=4010)

2000-2004 Keywords	F	2005-2009 Keywords	F	2010-2014 Keywords	F	2015-2021 Keywords	F
Computer mouse	3	Virtual reality	21	Virtual reality	48	Virtual reality	264
Virtual reality	3	Rehabilitation	12	Cerebral palsy	22	Augmented reality	88
Multimedia	2	Assistive technology	5	Visually impaired	21	Autism	82
		Multiple sclerosis	5	Augmented reality	16	Multiple sclerosis	72
				Autism	16	Rehabilitation	70
				Physical activity	14	Autism spectrum disorder	63
				Rehabilitation	14	Assistive technology	59
				Multiple sclerosis	12	Accessibility	57
				Walking	10	Smartphone	55
						Cerebral palsy	54

Table 7. Top 10 categories based on total publications. (n=125)

	Category	Number of publications
1	Engineering, Electrical & Electronic	448
2	Rehabilitation	326
3	Computer Science, Theory & Methods	306
4	Computer Science, Information Systems	227
5	Computer Science, Interdisciplinary Applications	198
6	Engineering, Biomedical	197
7	Computer Science, Artificial Intelligence	176
8	Computer Science, Cybernetics	173
9	Clinical Neurology	143
10	Neurosciences	131

Table 8. Top 10 journals based on total citations. (n=1184)

	Journal	Times cited	Number of publications
1	Journal of Autism and Developmental Disorders	875	15
2	Gait & Posture	681	16
3	Research in Developmental Disabilities	570	17
4	Archives of Physical Medicine and Rehabilitation	509	9
5	Plos One	485	19
6	Journal of Neuroengineering and Rehabilitation	412	21
7	IEEE Transactions on Neural Systems and Rehabilitation Engineering	388	18
8	Cyberpsychology & Behaviour	357	5
9	Sensors	311	44
10	Neuropsychologia	305	3

Figure 1. PRISMA flow diagram of the bibliography selection process

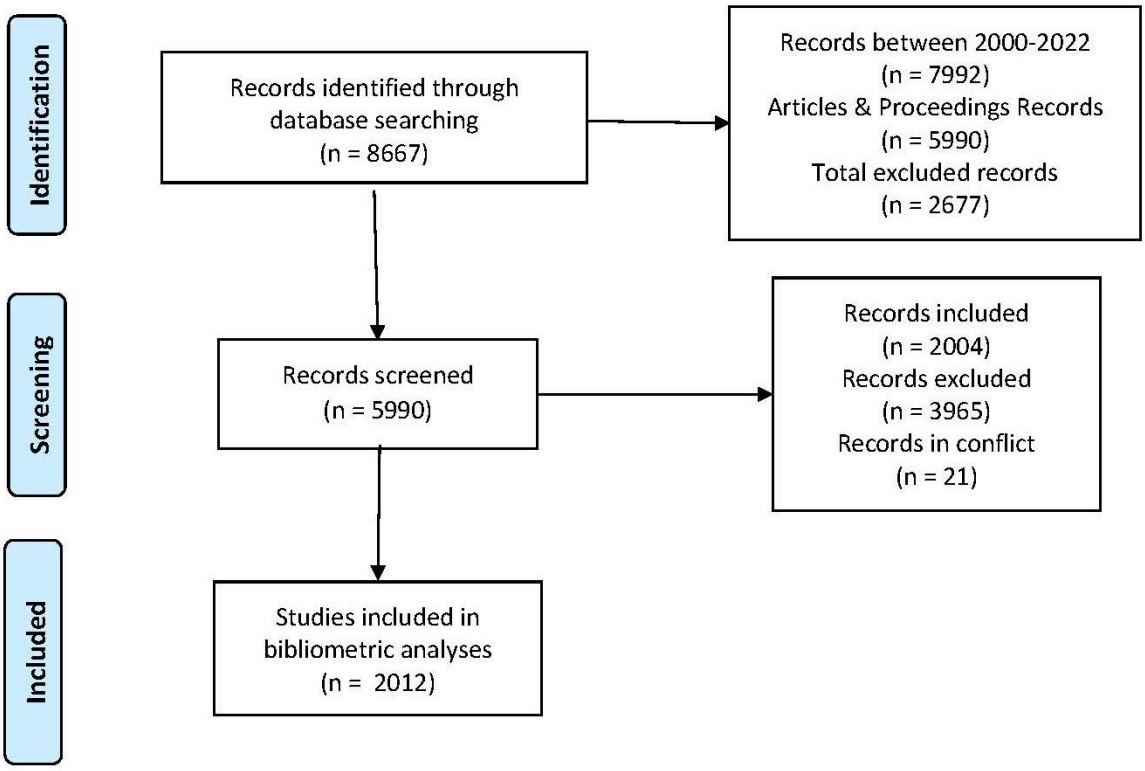

Figure 2. Mobile and wearable technologies for people with disability publications between 2000 and 2021.

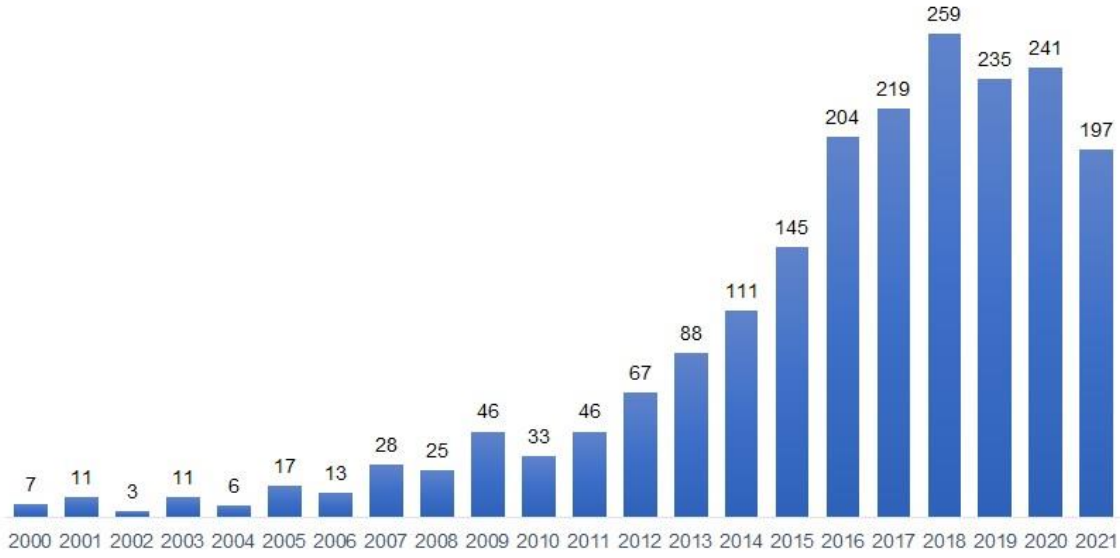
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Figure 3 Map of co-authorship

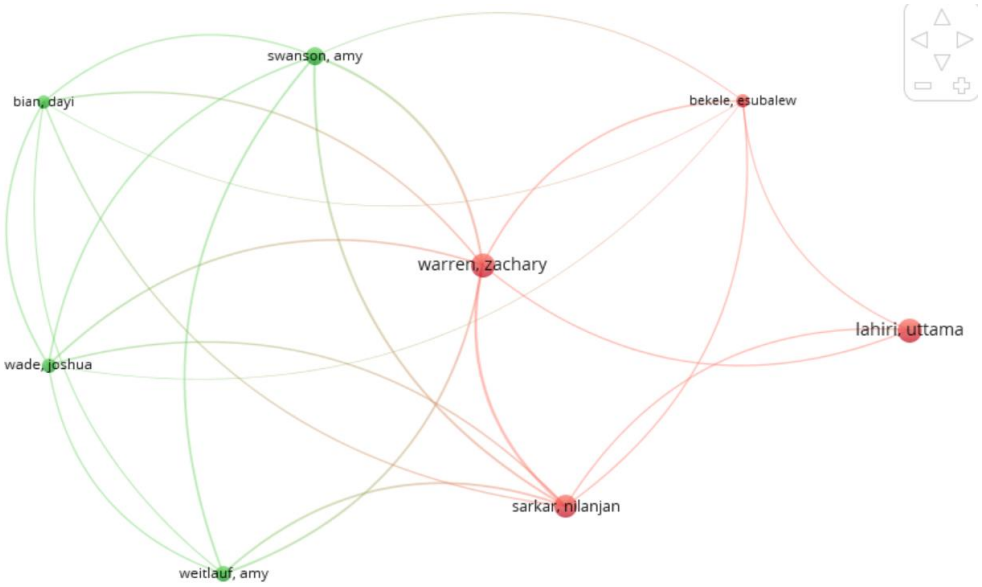
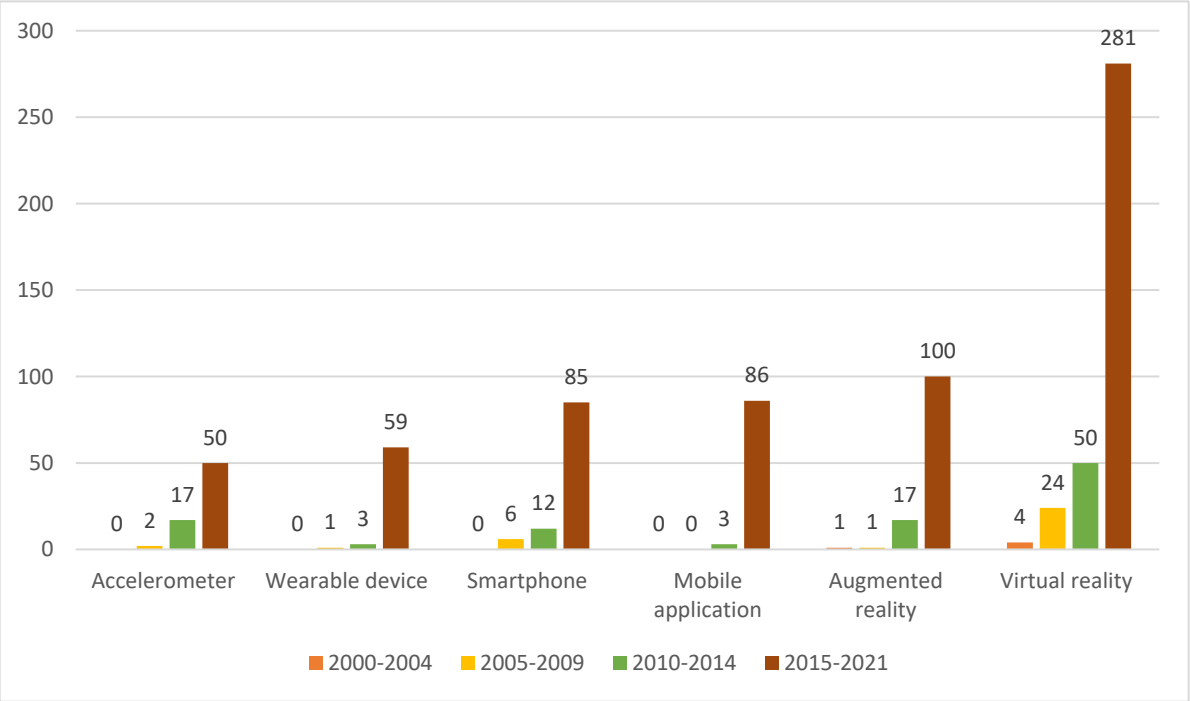


Figure 4. Trend of technologies between 2000 and 2021



(1) Figure 0: PRISMA flow diagram of the bibliography selection process

Alt text: 3 rectangles arranged vertically representing the process of screening 8667 initially selected records to 5990 records and finally 2012 records after two rounds of screening. A rectangle next to each of the first two rectangles shows number of included and excluded records in each round of screening.

(2) Figure 1: Mobile and wearable technologies for people with disability publications between 2000 and 2021.

Alt text: 22 blue coloured bars having numerical labels over them. These bars represent total number of publications over the years from 2000 to 2021. The bar size gradually increases from left to right showing increase in the number of publications related to mobile and wearable technology and disability over the years.

(3) Figure 2: Map of co-authorship

Alt text: Eight dots having multiple connectivity in an overlay visualisation pattern showing bibliographic coupling of the co-authors from various countries.

(4) Figure 4: Trend of technologies between 2000 and 2021

Alt text: 6 groups of bars showing the frequencies of technologies used as keywords of the selected publications on 5-year intervals from 2000 to 2021. Each group represents

a technology from accelerometer, wearable device, smartphone, mobile application, augmented reality, to virtual reality. The bars in each group increase over time, with the bars of virtual reality being the highest among all technologies.